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The Production of Alloy Steel Castings

Persistent research has enhanced the physical properties of steels to a remarkable degree, and the steel foundry is adapting itself to these developments by producing castings in which the material is comparable with the different grades of wrought-steel products. In this article progress in the production of steel castings is discussed with special reference to the work at the Clyde Alloy Steel Co., Ltd., Motherwell.

NOT so very long ago the range of physical and other properties possessed by steels in the form of castings was somewhat limited, the soundness of the metal in castings frequently was in doubt, and the finish or skin on the castings left much to be desired. Since the war, however, the interest aroused in alloy steels for many wrought products has been appreciated in the foundry, and to-day, in addition to ordinary steel, castings are being produced in practically all the alloy steels which have been developed in recent years. These include the high-tensile alloy steels, corrosion-, acid-, and heat-resisting steels, wear-resisting steels, and steels possessing magnetic properties.

Stobie electric-arc furnaces in operation at the works of The Clyde Alloy Steel Co.

Steel castings have always been considered the most difficult type of castings to produce, and although considerable attention has been given to this branch of the foundry industry in recent years, they may still be so regarded. Steel, as is well known, is a complex material, and it is doubtful whether any other metal or alloy approaches it in its capacity for modification of properties with slight changes in composition, but, in addition to the necessity for care in the composition to obtain the desired properties, the problems associated with the production of the castings are increased by the use of alloys. In many modern foundries, however, where attention has been concentrated on alloy steel castings, improved technique has resulted in remarkable progress, and steel castings are now regularly being made to specifications covering a wide range of physical and other properties; indeed, so great is the progress that castings are being produced in which the material is in some respects comparable with the different grades of wrought-steel products.

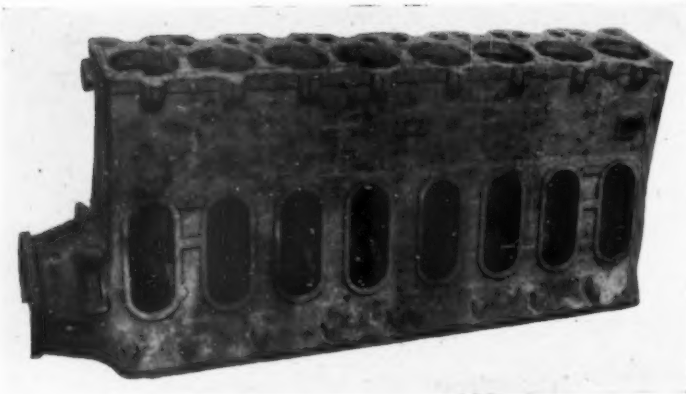
Formerly, steel castings were almost wholly of low-carbon steels, usually graded into low, medium, and high-carbon steels, but rarely did the carbon contents reach 0·5%. It is well known that with increasing carbon content greater strength is obtained, but decreased ductility; in order to preserve reasonable ductility, therefore, and to provide a casting with good shock resistance, the carbon content of the steel was kept as low as possible consistent with strength. As a result of persistent research, however, it was found that by adding special elements to the steel not only was it possible to increase its tensile strength, but also to ductility, and by increasing the percentages of these elements the steel possessed new characteristics. Although the number of elements which may be added to steel is relatively small, only about seven or eight being in intensive application, the range of combinations is very great. The elements more generally employed for alloy steel castings are silicon, manganese, nickel, chromium, molybdenum, and tungsten, and it is the application of these that has contributed to the progress of the steel foundry in recent years.

Effects of Various Alloys

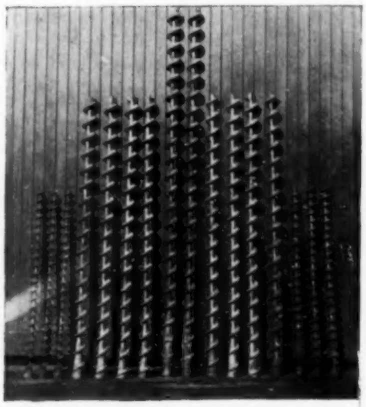
Taking into consideration the wide range of carbon contents, the varying amount of each alloying element and the anmy combinations of alloying elements used together, the number of steels of different composition is very great, and a detailed consideration of these steels, or even of all the main types, is out of the question in a short article of this character, but a brief reference to the specific effects of the alloying elements most commonly used will assist in a better understanding of their applications. Silicon and manganese are not usually regarded as alloying elements, but as they are used to confer particular properties, they are included.

Silicon.—It has been found that the addition of 2% to a 0·2% carbon steel increased the tensile strength and the yield-point without reducing the ductility, but probably the greatest economic value of silicon steel is due to its low magnetic hysteresis, high electrical resistivity, and good magnetic permeability. The cast silicon steels used for high magnetic induction differ little in composition from ordinary carbon steels excepting that the carbon, manganese, sulphur, and phosphorus is often lower with higher silicon.

Manganese.—This is one of the principal alloying elements employed when the austenitic condition is desired. It is used for steel parts which require to possess high resistance to wear, as in Hadfield's well-known



Alloy steel eight-cylinder aero-engine crankcase.



Coal-feeder worms for automatic stokers in an extremely tough wear-resisting alloy steel.

manganese steel, which contains 12% or more manganese. Its value in this connection is largely due to the instability of the austenitic structure under cold work or distortion, when it reverts to the martensitic condition, so that a manganese steel of this type subjected to abrasion develops an intensely hard skin, possessing very high resistance to wear, while retaining great toughness and ductility in the mass.

Generally, the tensile strength and elastic limit of a steel rise slowly with the increase of manganese content, while the elongation and reduction of area reduce slightly. Many steels are used possessing a manganese content between 1·0 and 2·0%, with carbon varying between 0·2 and 0·5%; they possess greater toughness and more resistance to shock than the higher carbon steel castings of similar strength.

Nickel.—This is also one of the principal elements employed when an austenitic steel is desired; the nickel austenitic steels, however, are more stable and, indeed, by a suitable adjustment of the composition can be rendered completely stable at ordinary temperature. Nickel is very versatile, and unites in all proportions, giving a wide range of usefulness. Low percentages increase the strength, yield-point, and hardness without loss in ductility, in both annealed and heat-treated steels; steels containing 20 to 30% of nickel are non-magnetic after cooling normally to ordinary temperature; with 30 to 40% of nickel the co-efficient of linear expansion is very low. Alloys containing higher percentage of nickel are used because of their magnetic properties. Nickel is particularly useful in conjunction with other alloys, notably chromium.

Molybdenum.—This element also increases the strength and resistance to shock, giving the steel a high elastic limit tensile ratio. In the heat-treated condition, molybdenum has the effect of promoting depth hardness. In many respects molybdenum and tungsten have somewhat similar effects on steel. Both these elements confer great stability under heat, particularly by maintaining high mechanical strength and hardness at high temperatures. Both greatly raise the tempering temperatures of steels, even when present in quite small quantities; the use of small amounts of molybdenum, in particular, as an addition to high-grade alloy steels, has had most beneficial effects on this account. This and its property of being able to counteract the effects of temper brittleness accounts for its use in highly-stressed complicated castings.

Chromium.—This is perhaps the most remarkable of the alloying elements, in view of its influence on the resistance of the steel to attack by chemical agencies, particularly oxidation and a wide range of acids. This element, which confers such marked resistance to corrosion, also has useful and beneficial influences on mechanical properties. In small percentages chromium is used to increase strength and hardness. The chromium content, however, covers a wide range from a fraction of 1% to a very substantial constituent of the steel. Among the latter are the stainless steel varieties and the special heat-resisting alloys.

Contraction Problems

Although only very brief reference has been made to the effect of various alloys on steel, it will be appreciated that their addition increases the problems encountered in the production of castings. The contraction of steel, for instance, is greater than that of many other metals, but no definite standard can be set, because it varies with the particular composition of the steel and also with the design. Castings of simple design contract more than those in which the design is complicated. Differences in metal thickness of a casting not only present shrinkage problems, due to the difference in the ratio of cooling of various parts of the same casting, but slow cooling influences the structure and performance of the steel. Solidification of the thicker sections may be accelerated by means of chills, in order to compensate for the difference in thickness, but there are limits to which chills may be employed.

The temperature of the metal as cast has a considerable influence on the resulting casting. For heavy castings, the steel may be cast at lower temperatures, providing it is sufficiently fluid to fill the moulds, in this way the degree of contraction during solidification and cooling is reduced. but the temperature of the metal is governed by the thinnest section, and to ensu re soundness in the thicker sections feeding must be resorted to. As is well known, solidification proceeds from the surface of the casting towards the centre of each section, and as the metal contracts it feeds upon that which remains fluid longest, compensating material must therefore be available to make good the metal in the centre of heavier sections. The extent to which feeding is necessary depends to some extent upon the temperature and also upon the composition of the steel.

Normally, the contraction of steel is rapid on solidification when in its weakest condition, and the mould must be weak enough to reduce the possibility of the casting cracking. Yet the m ould must be strong enough to resist the rush and pressure of the metal at the time of pouring. Even when the design of a casting is such that the metal may be cast at a low temperature, it will be appreciated that this is only a relative term, because the temperature is high when compared with the casting temperatures of other metals and alloys; the sand forming the cores and the faces of moulds must therefore be of high refractoriness and strong enough to resist erosion by the fluid metal.

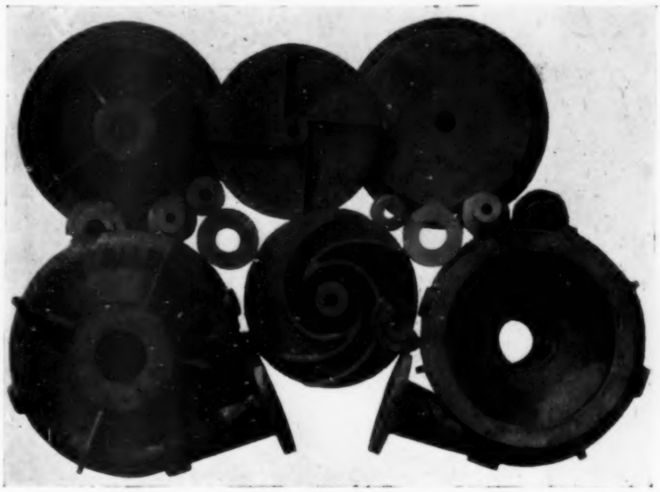
It may be said that the difficulties encountered in the production of other types of castings are intensified in the production of alloy steel castings, and when it is realised that the castings are subsequently given some form of heat-treatment to confer the most suitable grain structure and to produce the desired properties, it will be understood that the work in the alloy steel foundry is of a complex character. Many foundries have concentrated on particular types of alloy steel castings, but only a few, which may be classed as jobbing foundries, have developed the production of alloy steel castings to such a high level that practically all

types of these castings are on normal production. One of these is the foundry of the Clyde Alloy Steel Co., Ltd., at Motherwell, and brief reference to which will be of interest.

The Foundry of the Clyde Alloy Steel Co.

Although ordinary steel castings are made at this foundry, a large proportion of the output is alloy steel castings which are required to possess high strength combined with toughness, and resistance to impact, abrasion, corrosion, heat and/or high working pressures; purposes for which the limitations of ordinary steel castings preclude their use. It is equipped to make castings ranging from a few pounds to 10 tons in weight. Because of the jobbing nature of the work, practically all moulds are made by hand. Careful attention is given to the sand used. For heavy castings or heavy sections the facing sand is prepared from a naturally bonded silica sand, which is recognised as a high-grade moulding sand for steel castings.

The main foundry is in process of extension, owing to the increasing demand for high-duty steel castings, and additional equipment is being installed. When the extension is completed some slight rearrangement will be made to facilitate production. The melting furnaces are situated near the centre of one side of the foundry, with alloying metals stored on an adjacent platform which is an extension of the charging platform. Traveller cranes service this foundry, which is equipped with suitable core and mould drying ovens and annealing and heat-treatment furnaces. Considerable alterations and extensions are in progress in connection with a smaller foundry which is being laid out for small high-duty alloy steel castings, in which special hot-air stoves are used for drying cores and moulds.



Austenitic Ni-Cr stainless steel castings for centrifugal pumps used in the chemical industries.

Electric Furnace Plant

The melting plant in the main foundry comprises two 5-ton Stobie arc furnaces, which are equipped with three Stobie current and electrode economisers, and melt alloy steels with an electrode consumption of $6\frac{1}{4}$ lb. per ton of steel, taken over a year's working. Heats of steel are produced from each furnace in three hours, and require between 650 and 800 units per ton for the complete process, which is carried out with two slags, whether the steel is for plain carbon castings or for alloy steel ingots. The power factor of the furnaces averages 0·86, which automatically drops if there is a surge.

The furnace bodies are circular, and are supported on massive roller bearings for tilting. There are two doors on each furnace, one being in line with, but opposite to, the launder. Slags are run off the bath of steel through this door to avoid damaging the launder, as might happen if this were used for de-slagging.

The three electrodes of each furnace are supported on a rigid bridge which is fixed to opposite sides of the furnace, at right-angles to the launder. By this construction the furnace has clear space all around it, and scrap for successive heats can be placed on each side of the two working doors, which facilitates the quick charging and restarting of the furnace after the previous heat is tapped.

These furnaces have given, and are giving, good service, and the writer was informed on a recent visit to these works that they had given no trouble whatever. In addition to the electric-arc furnaces, a high-frequency electric furnace is installed, and an additional installation comprising a 1-ton capacity high-frequency furnace is on order from the Electric Furnace Co., Ltd., for erection in the foundry designed for the small intricate castings.

It will be noted that the manufacture of the requisite steel is effected in electric furnaces. In the arc furnaces a basic hearth is employed, ensuring a very low sulphur and phosphorus content. Manufacture of steel by the electric high-frequency process is the most recently developed process. In this latter process the energy induced in the charge causes movement of the molten metal, and this movement in relation to the slag can be used for refining purposes while accurate temperature control can be maintained. It is these processes which are being used to manufacture the highest grade of alloy steels for wrought products, and it is noteworthy that the castings produced at these works are of such a high order as to warrant nothing but electric furnace steel being used.

Co-operation between Designer and Foundryman

The successful production of alloy steel castings is dependent largely upon a proper conception of the requirements of a particular casting, its design, and also the degree of co-operation that exists between the designer and the foundryman. The Clyde Alloy Steel Co. readily advise on pattern construction, determine the contraction allowance to be made, and generally assist the designer in determining the most suitable form for reproduction as a sound casting. In alloy steel castings substantial heads must be cast on, and these frequently determine the way in which a casting should be made.

Fettling Castings

In addition to runners and heads, which must be removed from the castings, flashes and fins or small brackets, which have been cast on to reduce the possibility of fracture when cooling, are required to be cleaned off. The proper cleaning of steel castings is therefore a very costly operation, and necessitates adequate plant and machines. In these works the fettling is accomplished with the aid of the oxy-acetylene flame, pneumatic chisels and grinders, but where there is a danger of damage to the castings, as a result of internal strains, the castings are annealed before being finally cleaned.

Heat-Treatment

During recent years the heat-treatment of steel castings has received considerable attention, particularly those of a high-grade character. In the case of some alloy steel castings it is only by careful heat-treatment that full benefit from the alloys is realised. It is obvious, therefore, that the heat-treatment should be graded to suit the particular alloy steel and the design and size of the casting. No steel casting leaves the works of the Clyde Alloy Steel Co. without receiving some form of heat-treatment. This may take the form of annealing, normalising, or quenching, followed by tempering. For this purpose easily-controlled furnaces are necessary. At these works the annealing and

Grids and girders in heat-resisting steel for supporting brickwork in hot-blast stove.

heat-treatment furnaces are either fired by oil fuel or town's gas, and each furnace is under pyrometric control. Some reference to the various heat-treatments employed may be of interest.

Annealing.—At one time steel castings were raised to a red heat and then allowed to cool in the furnace, and in some foundries dealing with low-carbon steel castings this method may still be in operation. When the castings are to resist high stresses and the steel is to be submitted to exacting tests, as in the case of many alloy steel castings, the annealing practice must be carefully controlled. Steel castings are annealed to soften the steel and to render it more readily machinable or to meet certain physical specifications; to relieve internal stresses or strains, and to effect grain refinement. Full annealing necessitates heating above the upper critical range, at which an entirely new grain structure is produced. The exact temperature will depend upon the composition of the steel, but the minimum full annealing temperature should be above the A C3 point, to ensure the breaking of the coarse-cast structure.

The castings should be heated gradually, so that they will be heated uniformly throughout at the proper temperature, and they are retained at the annealing temperature long enough to develop the new grain structure and to relieve all internal stresses. In some cases the internal stresses are so great that it is advisable to transfer the castings to the annealing furnace while they are still hot, otherwise they may crack or actual rupture may take place. The castings are subsequently cooled slowly, usually in the furnace, depending upon the mass of metal in the sections.

Involute of wear-resisting alloy steel for suction dredger.

Normalising.—By this process the heating is carried out in exactly the same way and at similar temperature as when annealing, the only difference between the two treatments being that in normalising the castings are cooled in air. This treatment produces a finer structure, but it will be appreciated that where there are considerable changes in the sectional thickness of a casting there is a risk of it cracking through rapid cooling, and the structure of the metal inside the thick parts will conform to the annealed structure. With high-tensile steels the increased strength obtained by normalising usually results in reducing the ductility.

Quenching and Tempering.—In order to obtain the maximum physical properties from a high-tensile steel, a full heat-treatment is given. The castings are heated to a similar temperature as for normalising, and subsequently quenched in water or oil according to the composition of the steel. The castings are then tempered by reheating to a suitable temperature under the critical range—*i.e.*, below the A C1 point, and cooling in air. It will be appreciated that this treatment can only be given to castings in which the metal is almost uniform in thickness. As a rule, only special castings of small size are treated in this way.

Ingots, Billets, Bars, etc.

The Clyde Alloy Steel Co. was formed to develop the manufacture of alloy steels and steels of special composition, and to supply the increasing demand for higher tensile and alloy steels by the automobile and aircraft industries; production, therefore, is not confined to the making of castings: indeed the majority of the steels produced are for wrought products. They are cast into ingots and subsequently rolled to required sizes of bar, rod, or wire. It is noteworthy that all ingots and billets are machined before rolling, with the object of removing all surface blemishes which may reduce the quality of the steel. The section of the works dealing with this branch of alloy steel production is well equipped, not only for rolling, but for the complete heat-treatment of the steels, and includes bar-straightening machines and modern centreless grinders for the production of bright bar.

In the production of high-grade steel special care and attention must be given at every stage of manufacture, and the services of an expert metallurgical staff is essential to success. At these works there is an extensive laboratory which is staffed and equipped to control the quality of steel produced, so that it will conform to the most exacting specifications.

The writer takes this opportunity of expressing his thanks to the Clyde Alloy Steel Co., Ltd., for permission to visit these works, and for the photographs reproduced in this article, and to Dr. Hunter, for his courtesy and assistance.

Search for Oil Intensified

It has now been announced in official circles that the Government have granted to the Anglo-American Oil Co., Ltd., licences to search for petroleum covering nearly 500 square miles in the South of England. The preliminary survey for petroleum covers a very wide range of field research upon which this Company's geologists have been occupied for some months, and none but experts would appreciate the various obscure clues which indicate the possibility of oil being found. No pains or expense are being spared in the preliminary work, and should the next stage of their operations prove up to expectations everything possible will be done to develop to the full the producing and refining of any crude petroleum that may be found.

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Britain's Home and Export Trade

IT is a healthy sign of the times that the national trade figures are probably scrutinised now far more closely and commented upon much more freely than was the case before we learned what a real world depression could be like. Recent figures indicate a further speeding-up in the rate of increase in productive activity, which is primarily attributable to rearmament and domestic construction programmes. The improvement in business activity has extended to practically all branches of British industry, except coal and cotton, and has resulted in a substantial reabsorption of the unemployed.

Increased activity is specially marked in the capital equipment industries, shipbuilding, building and public works contracting, distribution and transport. On the other hand, the production of coal has depreciated. Pig iron output expanded from a monthly average of 604,000 tons in the first quarter of this year to 645,000 tons in the second. Similarly, steel output increased from 943,000 tons to 971,000 tons. The production of the steel industry in the first six months of 1936 reached a new high record, being nearly 12% higher than the first half of 1935. The shipbuilding figures for the second quarter disclose a further increase in activity. The tonnage under construction in Great Britain on June 30 was 848,732 tons, an increase of 6,371 tons during the quarter, and of 288,411 tons over a year ago. But, while appreciating the value of this increased activity, the progress in foreign shipbuilding yards should not be overlooked. Production abroad increased by 124,520 tons during the quarter to 1,102,273 tons.

It should be noted, however, that Britain's increased business activity is largely due to greater demands of the home market, her share of overseas trade during the first six months of this year has certainly increased by comparison with the similar period last year, but the actual figures are disappointing. The upward trend in exports, which was so encouraging a feature of the 1935 figures, has been arrested. The value of our exports during this half-year was only £1·4 millions, or 0·7% greater than in the first half of 1935, and in consequence the adverse visible balance of trade has risen sharply.

With the greater interest shown in the national trade figures, it might have been anticipated that we should have reached a stage when it would no longer be necessary to ask such elementary questions as, "Is export trade worth while?" Yet it is not uncommon to find people still doubting the wisdom and necessity of building up a flourishing overseas trade, and expressing the opinion that the pursuit of a favourable balance is a myth. Too often, of course, the issue is confused by other incidental considerations, such as foreign loans and the seeming paradox of exporting goods which could be consumed at home, giving purchasing power, etc. Without belittling the importance of these factors, they should not be allowed to detract from the overwhelming consideration that Britain must export to live.

No country can supply all its needs, least of all Great Britain, which is the greatest importer among the nations of the world. These imports must be paid for with exports or/and service. This applies in a varying degree to all nations, and it was because of the growing needs of civilisation that the system of international trade was built up with such care and labour during the 19th and early 20th centuries. But the breakdown of this system, commenced in recent years, is still proceeding, and although this country, of all highly industrialised countries, held out the longest against the topsy-turvydom of post-war economics, adjustments were essential to effect a balance between imports and exports. One of the most important features of the post-war period was the race for currency depreciation, and it must often be a source of wonder whether the governments of countries which had already depreciated their currencies to a far greater degree appreciated the humour of the situation which arose when they threatened the British Government with reprisals when this country was forced to go off the gold standard. It is true, of course, that Great Britain and the other members of the so-called sterling *bloc* derived some benefit from the depreciation of their currencies, as compared with the gold standard countries, but this is apt to be exaggerated.

Calculated in terms of present-day sterling, the increase in the export trade of Great Britain since 1932 has been only about 16%, and, of course, in addition to currency depreciation this country has had the advantages of a protected home market, the Ottawa Agreements, and the various commercial treaties concluded with the non-Empire countries. There has been substantial recovery in the domestic level of activity since 1932, but this has not resulted in so appreciable a recovery in the export trade. It is true that the export trade of all the industrialised countries has risen since the nadir of the depression, but in nearly all of them the level is far below that of 1929, a year not specially notable for its overseas activity. British exports in 1935, for instance, were still about 40% below the 1929 level.

The prospects of increased trade in the home market are good, and while the export trade is not making the progress many wish to see, an upward tendency is discernible. The prospect of contracts of considerable value from Russia, for instance, is a very encouraging sign. This improvement is based on the restoration and maintenance of confidence; the protection given to the home market, the development of overseas markets, largely under the stimulus of bilateral agreements with Empire and numerous foreign countries; and the influence of cheap money. These factors still operate, and the policy of developing oversea markets, through trade agreements, is being pursued. The volume of world trade is slowly expanding, and the international background seems less unfavourable than in recent months, but there are still too many disturbing influences which affect trade. The time will probably come when groups of governments, if not all governments, will decide among themselves that folly has run its course, and the doors be reopened to freer, if not too free, international trade. To achieve this object governments and nations will have to be at peace with each other, and, unfortunately, sanity in the political field is far from being in sight.

At the moment there are few signs of any real improvement in international trade. Apart from disturbing clouds on the political horizon, the resolution of the world's fundamental economic problem appears as remote as ever. The meaures by which the separate countries have sought to restore prosperity to their domestic markets have

involved both a progressive movement away from the old international structure, and an intensification of certain underlying conditions which, in any event, were destined to compel the world to change the direction of its economic evolution. There is a certain amount of encouragement in the fact that despite the growth of economic nationalism, the levels of prosperity in individual countries still tended to rise and fall together. The rise of industrial production is widespread, and as an exporting country Great Britain should benefit from this progress in other countries.

The Testing of Non-materials

A rather unusual address was given by the President, Mr. H. S. Vassar, at the recent annual meeting of the American Society for Testing Material, held in Atlantic City, in which he dealt with the testing of non-materials The problems upon which he briefly touched were unemployment, labour and the fomenting of hatreds. Our approach to the numerous problems which have to do with satisfactory living and which so vitally concern each one of us, was discussed by Mr. Vassar. We have, he said, several hundred associations of specialists in science and technology, with an aggregate membership of hundreds of thousands. In the treatment of the physical problems in their respective fields, a reasonably successful technique has been developed. This is generally described as the scientific approach, but common sense would be just as good a name. But is there any valid reason for abandoning these methods of approach when stepping, as we must, from our vocation into the non-materials field ?

It has been said that a few thousand people are sufficient at any time to change the thinking of America. If this is true, there is within the organised workers in the field of physical science a potential force fully capable of being the leaven in the meal of society, which can aid mightily in the development of a more rational approach to the problems of the day.

In concluding his address Mr. Vassar stated that on the celebration of Independence Day, we are asked to remember those men of 1776 who sacrificed their comfort, their possessions, and in many cases, their lives in the common interest. The challenge that comes to Americans in 1936 is less spectacular. It may not be a call to physical combat, but it does demand honest, intelligent, and unselfish thinking as each one does his part in bringing adequate standards to the testing of non-materials.

Protective Glasses for Welders

The metallic arc is a source of intense light, and it is very necessary that the welder should have complete protection from the injurious effects of the radiations from the arc in the eyes. The usual type of protective glass consists of either a combination of two or more glasses of different colours fastened together at the edges, or a single glass coloured by the addition of suitable materials during the making of the glass.

Both forms of glass suffer from one common fault and that is that it is very difficult to keep the density of the colour uniform, so that out of the same batch some glasses may be much lighter or darker than the standard. This means that, when using a glass, the welder either cannot see the work properly or else he is fatiguing his eyes by having too much light striking them. It is important, therefore, that a standard density should be fixed and adhered to, in order that, whatever the colour of the glass, it should give the same protection against fatigue.

The new "Lamurex" protective glass for welders is manufactured on a principle which makes the producton of a protective glass of standard density a simple matter. It consists of a special form of light filter of definite thickness and pre-determined colour density cemented between two sheets of glass. These glasses, which are manufactured by Murex Welding Processes, Ltd., are made in three grades, to meet the requirements of various trades.

Forthcoming Meetings

INSTITUTE OF METALS.

Sept. 14–18—Autumn Meeting in Paris, by the invitation of the Bureau International des Applications de l'Aluminium with the co-operation of the Chambre Syndicate des Metaux à Paris.

TECHNISCHER HAUPTAUSSCHUSS FÜR GRESSEREIWESEN.

Sept. 16–20—The International Foundry Congress at Dusseldorf. Arrangements are being made by the Institute of British Foundrymen and the British Cast Iron Research Association to attend this Congress.

IRON AND STEEL INSTITUTE.

Sept. 21–26—Autumn Meeting in Dusseldorf by the invitation of the Verein Deutscher Eisenhüttenleute acting on behalf of the German Iron and Steel Industry

First Soviet Tube-making Machine Working Satisfactorily

The first Soviet-made machine for the production of cold-rolled tubes, designed by the Central Bureau of Heavy Machine Building, has been tested and found satisfactory at the Ilyich Metallurgical Plant in Mariupol in the Ukraine. Having many advantages over the drawing method, the cold rolling of tubes simplifies the process of tube production, eliminates waste of metal and makes possible more accurate workmanship. A machine for the cold rolling of tubes has a productivity of up to five metres of tube per minute, and thus replaces approximately from five to six tube-drawing machines.

A. P. Karpinsky, the Soviet Scientist of World Renown

In the death of Academician A. P. Karpinsky, on July 15, the Soviet Union has lost one of its leading scientists. Born in 1847, he graduated in 1866, and began his practical and scientific activity in the Urals. With the well-known geologist, G. D. Romanovsky, he conducted geological prospecting work for gold in the Southern Urals and northwards up to the Bogoslovsk mining district. In 1868 he was appointed Assistant Professor of Geology, and soon afterwards to the Chair of Geology at St. Petersburg Mining Institute. Recently, he celebrated the fiftieth anniversary of his election to the Academy of Science of the U.S.S.R. This almost coincided with the twentieth anniversary of his uninterrupted presidency of the Academy.

An outstanding scientific and social worker of the Soviet Union, Academician Karpinsky was at the same time a distinguished world scientist. He is justifiably considered to be the father of Soviet geology. He devoted many years of his scientific activity to an extensive investigation of the geological structure of the eastern slopes of the Urals, and was the first to present a geological picture of the whole European part of the Soviet Union, from the shores of the Arctic Ocean to the foothills of the Caucasus.

He discovered a new stage hitherto unknown to science, the Artinskian stage of the Permian system. The extensive oilfields of Ishimbayevo, which form to a great extent a second oil base of the Soviet Union in the East, were recently discovered to be in this stage of geological evolution.

Only a year ago he was in London to take part in the celebrations on the occasion of the centenary of the geological service in England, and before he died he was taking an active part in the preparations for the seventeenth International Geological Congress, which is to take place next year in Moscow.

The Spoilage of Non-Ferrous Components by Acid Treatments

By E. E. HALLS

Insufficient attention is given to the formulation of acid mixtures, immersion temperature, and time when acid-dip treatment is necessary to the finishing treatment of non-ferrous components, and the results are often disastrous. These factors are discussed in this article, and control suggested; suitable acid dips are recommended.

VERY few surface finishing treatments for articles fabricated from the common non-ferrous metals and alloys can be carried out without some form of acid-dip treatment being involved as a preparatory process. The finishes concerned will include all the electro-plate coatings, bright acid treatments, and various clear lacquer finishes. Also, heat-treated non-ferrous metals will be acid cleaned between operations to remove annealing scale and to assist drawing or forming. If the practice of metal finishing departments in general engineering industries is examined, it will become apparent the people in charge are prone to allow work to be acid-treated rather indiscriminately, without appreciating that the action of the acid is to cause metal to be dissolved and to promote irregular pitting. Inhibitors for nitro-sulphuric dips and similar acid mixtures have not yet been developed, and therefore the same safeguards that are employed in the pickling of iron and steel are not available. Consequently, reliance must be placed upon the formulation of suitable acid mixtures, immersion temperature, and time. It is evident that these factors are not given the attention they merit, often with disastrous results. Unless a completely mechanised department exists, in which case time of immersion is automatically controlled, very little chance of obtaining uniform results with pernicious acid mixtures is practicable. Consequently, reliance should be given to the use of acid solutions which effect the desired result from the appearance viewpoint with the minimum of dissolution or attack on the base metal. Most finishing shops work on a piece-work basis, and the tendency is for acids to be employed which function most rapidly, and particularly does this seem to be the aim where the condition of a batch of articles is rather non-uniform. In the latter instance, the tendency is to select a dip which caters most readily and rapidly for the worst condition, and which quickly produces on all surfaces an appearance of closely similar standard. However, not only does this rigorous form of treatment fail always to produce a uniform condition, frequently damaging the surface of the work irretrievably, but also excessive metal must of necessity be removed in such cases.

Acid-Clean Brass Work

Brass work forms a large proportion of the base metals concerned in this class of finishing. Bright finishes and electro-nickel plate are exceedingly popular forms of finish that have to be cheaply but efficiently produced. Owing to the facility with which soft brass can be formed into complicated shapes with appropriate annealing treatments interposed between operations, it may not be unusual for a brass article to be subjected to five or six acid cleans before it is ready for final finishing. Few of the people concerned with this class of work realise the amount of metal which can be removed during a short-time immersion in a vigorous acid dip. Plating shop operators, with the work wired or in baskets, giving it a number of successive immersions, the total time of a single complete "dip" comprising several such immersions varying from 15 to 30 secs., is not an unusual sight. Due to mass production, and to facilitate assembly, articles are produced to close dimensional tolerances, while on threaded portions and tapped holes obviously no tolerance beyond that essential to the machine shops can be allowed if firm mating is to be ensured. These exigencies render it doubly imperative that any acid treatment, particularly where several are involved, shall not cause work to fall outside the dimensional limits fixed. Average tolerances to which the machine shops work range from 0·0005 in. to 0·004 in.

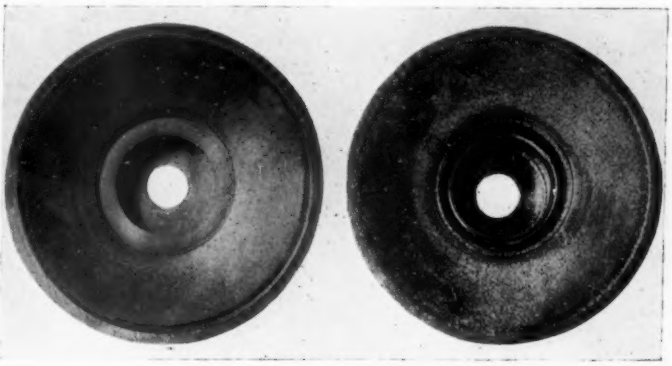


Fig. 1.— Slightly reduced Fig. 2.— Comparison in results from diffierent acid dips used in practice.

In common practice, brasswork is dipped in solutions of nitric acid or of a mixture of nitric and sulphuric acid. Popular mixtures are as follows, concentrations being by volume :—

TABLE I.

Reduction in Thickness of 70/73 Brass Sheet on Acid Dipping in Cold Nitric Solutions.

Immersion period, 30 secs.

Dimensions in Inches.

Test No.	Commercial Nitric Acid.	3 Parts Nitric Acid, 1 Part Water.
1	0·0020	0·0030
2	0·0020	0·0018
3	0·0021	0·0021
4	0·0027	0·0024
5	0·0022	0·0022
Mean	0·0022	0·0023

These are intended for use cold, but numbers 3, 4, and 5 become hot during mixing, and all of them become hot during the dipping operation. It is usual to have the tanks cold-water jacketed. From this range of solutions selection is frequently made on the basis of numbers 1, 2, or 3 for comparatively heavily-scaled work and number 4 or 5 for relatively bright work or as a final rinse after using one of the first group.

To quote a specific instance in the writer's experience, on a brass pressing from 0·064 in. sheet, with various piercings, 6 B A tapped holes, and formed lugs, all important because they were concerned with fitments which when mounted had all severally to be in position accurately with relation to one another, was specified a flash nickel-plating. It is to be noted that the part was made from bright rolled brass sheet purchased to standard thickness tolerances, and involved no intermediate annealing operations. Con-

sequently, the only acid treatment needed prior to plating was a light etch to provide the requisite adhesion. On assembly it was found that screws fell through the tapped holes, bearings were loose in bushes, the profile of lugs was spoiled, and mounted parts did not align. Investigation showed 30% of the parts were irreparably damaged, and the remainder were only recoverable by redrilling and tapping the holes to take larger screws. The average reduction in thickness of the 30% faulty parts was 0·015 in., with a weight reduction of $\frac{3}{8}$ oz. on 5 oz. Vigorous over-pickling was the cause of the trouble, both time and acid composition being evidently wrong. The possibilities in these directions can be seen from Tables I. and II., the data in which all refer to a period of 30 secs. immersion.

TABLE II.

REDUCTION IN THICKNESS OF 70/30 BRASS SHEET ON ACID DIPPING IN NITRIC/SULPHURIC ACID MIXTURES.

Immersion period, 30 secs.
Dimensions in Inches.

Test No.	1 Part Sulphuric Acid, 3 Parts Nitric Acid.	3 Parts Sulphuric Acid, 1 Part Nitric Acid.	4 Parts Sulphuric Acid, 3 Parts Nitric Acid. 1 Part Water.
	Cold.	Cold.	Cold.
1	0·0009	—	—
2	0·0012	—	—
3	0·0013	—	—
4	0·0007	—	—
5	0·0006	—	—
Mean	0·0009	0·00005	0·0002
	Hot (70° C.)	Hot (70° C.)	Hot (70° C.)
1	0·0015	—	—
2	0·0008	—	—
3	0·0009	—	—
4	0·0013	—	—
5	0·0010	—	—
Mean	0·0011	0·0002	0·0003

Table I. deals with the dipping of brass in nitric acid solutions, and Table II. in nitric/sulphuric acid mixtures. The rôle of the nitric acid constituent as the dissolving agent is plainly evident. The plain acid in the period removes over 0·002 in. of metal, the diluted acid dissolves about the same, but in a more uneven manner. The presence of 25% of sulphuric acid has a restraining influence, approximately 0·001 in. being removed. The heat of acid-mixing may cause this to be a little higher, but more irregular. With higher sulphuric acid content, the restraining influence is still more marked, and practically complete at 75% addition, this mixture being effective in removing tarnish and light oxide, with the production of a bright, clean, almost invisibly etched surface. Used hot, this mixture still is not deleterious. The intermediate mixture containing both acids and water is a little more vigorous than the high sulphuric acid content solution, but a long way short of the dissolving activity of the high nitric acid content mixture.

The components complained of for over-dipping must not only have been processed in a high nitric acid content solution, but also must have been left immersed for an unduly excessive period. Some of the trouble may have arisen from the practice of replacing drag-out, and keeping dips " live," by frequent periodic additions of nitric acid, thus gradually tending towards an all-nitric dip.

Another objectionable feature of over-dipping brasswork, whether nickel-plating or a bright brass finish is entailed, is the pronounced etching effect. This may result in an irregular frosted finish or a deeply pitted appearance, with the original defects in the metal surface greatly enhanced. It is to be noted that while the first defect concerned dimensions, this second fault is a shortcoming even where dimensions are unimportant. The attached photographs are of pressings from 70/30 brass sheet, five severe press operations with four interprocess anneals, each with its subsequent acid clean, being entailed. Nickel plating is the final operation. Both photos are about two-thirds actual size. Fig. 1 reveals no pitting in excess of what is to be expected from a heavily pressed up article, whereas that in Fig. 2 is a mass of imperfections. The reasons for this lie in the following: The work corresponding to Fig. 1 was pickled after each anneal for 30 secs. in a 10% solution of sulphuric acid in water, this being sufficient to remove heat-treatment exide entirely without any attack on the base metal itself. Before plating, it was subjected to a light dip of 2 to 3 secs. in No. 4 solution (1 nitric, 3 sulphuric). The work corresponding to Fig. 2 had been given dips in No. 3 solution (3 nitric, 1 sulphuric) at each stage of acid treatment. The benefits of the one, and the disadvantages of the other, are clearly evidenced from visual examination.

Bright Treatment of Phosphor-Bronze Components

Phosphor bronze (tin/copper alloys) is another non-ferrous material subjected to bright acid-dipping treatments for final finish or as preliminaries to nickel-plating. It is a popular material for springs, many of which are made from thin gauge strip or sheet. It is not one of the easiest of materials to roll without having surface blemish. Vigorous acid-dipping accentuates these defects, as well as revealing those which have been flowed over by the surplus metal from the final rolling pass. Upset to dimensions may be just as serious as with brass. In the latter connection, the influence of acid-dipping can be seen from the data given in Tables III. and IV. The moral drawn is the same as in the case of brass-dipping, the violent dissolving power of nitric acid must be suppressed. In one particular instance where haphazard dipping was practised, a retaining spring, cup-formed, without any annealing operations, and reaching nickel-plating in a bright condition, it was found after nickel-plating that 50% of the product was defective, because thickness sas reduced from 0·012 in. to 0·008 in. Also, by differential etching, the rolling marks and blemishes in the material were thrown into strong relief and caused criticism from the customer.

TABLE III.

REDUCTION IN DIMENSIONS OF PHOSPHOR BRONZE ON IMMERSION IN NITRIC ACID PICKLES.

Immersion time, 30 secs.
Dimensions in Inches.
Acid Composition by Volume.

Test No.	Commercial Nitric Acid, S.G. 1·42.	3 Parts Nitric Acid, 1 Part Water.
	Cold.	Cold.
1	0·0037	0·0015
2	0·0022	0·0018
3	0·0041	0·0018
4	0·0036	0·0014
5	0·0034	0·0016
Mean	0·0034	0·0016
	Hot (70° C.)	Hot (70° C.)
1	0·0067	0·0040
2	0·0065	0·0038
3	0·0080	0·0046
4	0·0086	0·0041
5	0·0052	0·0036
Mean	0·0070	0·0040

TABLE IV.

REDUCTION IN DIMENSIONS OF PHOSPHOR BRONZE ON IMMERSION IN NITRO-SULPHURIC ACID PICKLE.

Immersion time, 30 secs.
Dimensions in Inches.
Acid Composition by Volume.

Test No.	3 Parts Nitric Acid. 1 Part Sulphuric Acid.	1 Part Nitric Acid, 3 Parts Sulphuric Acid.	1 Part Nitric Acid, 1 Part Sulphuric Acid, 5 Parts Water.
	Cold.	Cold.	Cold.
1	0·0007	0·0000	0·0000
2	0·0005	0·0000	0·0000
3	0·0004	0·0000	0·0000
4	0·0003	0·0001	0·0001
5	0·0007	0·0001	0·0000
Mean	0·00052	0·00004	0·00002
	Hot (70° C.)	Hot (70° C.)	Hot (70° C.)
1	0·0010	0·0001	0·0001
2	0·0009	0·0001	0·0001
3	0·0006	0·0004	0·0002
4	0·0010	0·0002	0·0002
5	0·0006	0·0002	0·0002
Mean	0·00082	0·0002	0·00016

Nickel Silvers

Nickel silvers (nickel/copper/zinc alloys) are a third group of popular alloys which in the light electrical trades are put into service with only a bright acid-dip finish. In automatic apparatus operated by electrical impulses, flat type springs are almost invariably made from 18% nickel silver. Their adjustment, tensioning, and correct operation depend almost entirely upon these springs being maintained within close dimensional tolerances or thickness. For example, the B P O tolerances range from plus or minus 0·0005 in. to plus or minus 0·0010 in. for material up to 0·020 in. Again, acid-treatment develops those surface blemishes which are barely apparent in the stock, and reveals superficial dezincification as light brass-coloured areas. The modern tendency is to restrict processing of these springs to an alkaline clean, due to the fact that finishing shops in general are liable to overlook these pernicious effects of acid dips. In one case recorded of a thin, formed spring, the reduction in thickness was sufficient to destroy the required rigidity of the spring; in this case the original thickness was 0·008 in., and the final value 0·0045 in.

TABLE V.

REDUCTION IN DIMENSIONS OF NICKEL SILVER ON IMMERSION IN NITRIC ACID PICKLES.
Immersion time, 30 secs.
Dimensions in Inches.
Acid Composition by Volume.

Test No.		Commercial Nitric Acid, S.G. 1·42.		3 Parts Nitric Acid, 1 Part Water.
		Cold.		Cold.
1	..	0·0011	..	0·0027
2	..	0·0012	..	0·0022
3	..	0·0013	..	0·0032
4	..	0·0012	..	0·0027
5	..	0·0013	..	0·0029
Mean	..	0·0012	..	0·0027
		Hot (70° C.)		Hot (70° C.)
1	..	0·0136	..	0·0081
2	..	0·0125	..	0·0075
3	..	0·0120	..	0·0092
4	..	0·0129	..	0·0094
5	..	0·0119	..	0·0082
Mean	..	0·0126	..	0·0086

TABLE VI.

REDUCTION IN DIMENSIONS OF NICKEL SILVER ON IMMERSION IN NITRO-SULPHURIC ACID PICKLE.
Immersion time, 30 secs.
Dimensions in Inches.
Acid Composition by Volume.

Test No.		3 Parts Nitric Acid, 1 Part Sulphuric Acid.		1 Part Nitric Acid, 3 Parts Sulphuric Acid.		1 Part Nitric Acid, 1 Part Sulphuric Acid. 5 Parts Water.
		Cold.		Cold.		Cold.
1	..	0·0007	..	0·0003	..	0·0003
2	..	0·0003	..	0·0001	..	0·0005
3	..	0·0002	..	0·0002	..	0·0002
4	..	0·0003	..	0·0002	..	0·0002
5	..	0·0003	..	0·0001	..	0·0004
Mean	..	0·00036	..	0·00018	..	0·00032
		Hot (70° C.)		Hot (70° C.)		Hot (70° C.)
1	..	0·0006	..	0·0001	..	0·0004
2	..	0·0011	..	0·0001	..	0·0004
3	..	0·0008	..	0·0002	..	0·0006
4	..	0·0006	..	0·0001	..	0·0007
5	..	0·0009	..	0·0001	..	0·0005
Mean	..	0·00080	..	0·00012	..	0·00052

No. 1. 50/50 nitric acid and water.
,, 2. 3 parts nitric acid, 1 part water.
,, 3. 3 parts nitric acid, 1 part sulphuric acid.
,, 4. 1 part nitric acid, 3 parts sulphuric acid.
,, 5. 3 parts nitric acid, 4 parts sulphuric acid, 1 part water.

Tables V. and VI. contain data appertaining to the effects of acid-dipping upon dimensions. From these it appears that nickel silver is just as extensively attacked if not more so, as brass and bronze.

If thought is given to the subject, and control is instituted to take care of these matters, it is possible to instal suitable acid dips for these metals, with little possibility of deleterious effects being created. Using the ordinary commercial type of compositions, the following recommendations can be made :—

Recommendations for Brass and Phosphor Bronze (and Copper)

(*a*) *For Removal of Heat-treatment Oxide.*—Short period immersion in cold 10% aqueous sulphuric acid solution. Note: For thick scales the same mixture is satisfactory, but removal can safely be accelerated by heating to 60°–70° C.

(*b*) *Prior to Nickel-plating.*—Short period dip in mixture of three parts sulphuric acid, one part nitric acid.

(*c*) *For Bright Finishing.*—Short period dip of 2 to 5 secs. in mixture of three parts nitric acid, one part sulphuric acid, followed by quick dip in a mixture of three parts sulphuric acid, one part nitric acid.

For Nickel Silver

(*a*) *For Removal of Heat-treatment Oxide.*—Immersion in a mixture of one part nitric acid, one part sulphuric acid, and five parts water. This is used cold for light scales, and hot (up to 70° C.) for heavier scales, with a maximum period of 5 mins. if heated acid is employed.

(*b*) *Prior to Nickel-plating.*—As for brass.

(*c*) *For bright Finishing.*—As for brass.

Finally, it is pointed out that an excellent method of surface preparation applicable to brass has been developed by the British Non-ferrous Metals Research Association. It provides the minimum of etching of the base metal, and the maximum of adherence for the nickel coating—in fact it can be applied to polished work without detriment to the polish. This refers to the citric acid etch. The solution is prepared from 50 grms. of citric acid in water, exactly neutralised with ammonia, and then a further addition of 20 grms. of citric acid in water is made, and the whole diluted to 1 litre. This solution is employed cold and the work anodically etched at a low current density of 5 to 10 amperes per sq. ft. The processing period is of the order of 30 secs. This in itself should go a long way towards eliminating finishing troubles of the type discussed.

Physical Constants of Pure Metals

A CONSIDERABLE number of physical constants of pure metals have been determined during the past 15 years at the National Physical Laboratory, Teddington. The results have now been collected, and are published in a pamphlet in a convenient form for reference.

Part I. of the pamphlet contains data for some specially pure metals which have been prepared in the course of researches at the Laboratory. The metals are iron, chromium, manganese, beryllium, cadmium, magnesium, and tin, and tables are also included giving the surface tensions of liquid metals, and the lattice parameters of various metals.

Part II. contains results obtained on metals of known high purity procured from external sources. Data are given for melting points, latent heats of fusion, specific heats, thermal conductivities, and coefficients of expansion. The results of measurements made in other institution have, in many instances, been included, thus bringing together results which are later than those contained in the International Critical Tables.

"Physical Constants of Pure Metals." H.M. Stationery Office, London, price 6d. net.

The output of "base metals" is an excellent index to world industrial activity. It is, therefore, gratifying to note that a marked feature in the latest traffic returns of the Rhodesian Railways is an increase in the amount of chrome ore handled. During May, 20,000 tons were carried to the coast for export, an increase of 9,406 tons over the preceding month, and 10,355 tons over May, 1935. A total of 5,058 tons of asbestos was carried during May, 1936, as opposed to 3,885 tons in April and 4,153 tons in May last year.

Electrically-produced Heat

Some aspects of electric heat discussed at the recent general meeting of German Chemists.

At the recent general meeting of German Chemists, held in Munich, considerable attention was given to electric heat, and several papers were devoted to various aspects of this subject. In discussing the selection of materials for the electrical generation of heat, as applied to the chemical industry, Dr. W. Hessenbruch stated that the essential part of the electric resistance furnace is the heating conductor. The selection of the material for this conductor is therefore of the utmost importance, particularly where special conditions obtain in the chemical industry with respect to atmosphere and the further surroundings of the heated conductors.

The most important metallic and non-metallic materials for heated conductors were discussed with reference to their characteristic features (specific resistance, resistance to heat, surface load, maximum practical working temperature. The metallic heaters were classified under the following headings: Alloys, whose specific resistance is comparatively small and whose co-efficient of temperature is low, such as Nickelin and Constantan; alloys of medium specific resistance at room temperature and relatively high temperature, such as chromium steels, nickel-chrome steels, and low-alloyed chrome-aluminium steels; alloys of high specific resistance and moderate temperature co-efficient, such as chrome-nickel alloys; alloys of particularly high electric resistance and very low temperature co-efficient, such as highly alloyed chrome-aluminium steels.

A brief description of the tests on the durability of different materials suitable for conductors at high temperatures were given, and a few interesting cases of corrosion in connection with conductors operating under special conditions were discussed—*e.g.*, the attack by sulphur and carbon, chlorine, chlorides, or fluorides, the influence of enamels and silicates, and also the absorption of nitrogen by the highly alloyed chrome-aluminium steels. The most suitable materials for conductors for the most important fields of application were communicated in the form of a table.

Temperature Measurement

Recent results on errors in measurements of temperatures were discussed by Prof. Dr. R. Hase, who considered that with the more settled phase in the development of pyrometer construction it is seen how difficult it often is to secure correct temperature values, and what errors affect many measurements, despite excellent equipment. An improvement can be secured only by devoting greater attention in practice to the critical evaluation of the instrument readings and by varying the method in doubtful cases, if at all possible.

The effect of temperature errors was discussed, with reference to three characteristic examples: (1) The determination of the temperature of surfaces of solid bodies; (2) of gases; and (3) of radiating bodies; and in the latter sphere more especially, surprising and particularly valuable results are due to the introduction of the colour pyrometry in the iron industry.

The aim of all in charge of temperature measurements in engineering practice, however, should be to obtain true values and not to be content, as so often happens, with the more convenient, but frequently risky, so-called relation measurements. Only in this way will it be possible to reach an interchange of experience between work of similar character.

Temperature Control

In dealing with the electric control of temperature, Dipl. Eng. H. O. Meyer said that almost all chemical processes require a certain predetermined temperature to be maintained in order to warrant a favourable course. The maintenance of an even temperature can, in many cases, be effected in a simple manner by hand, but mostly it will prove necessary to adopt automatic control. Results may thereby be permanently obtained, subject to correct selection and application, providing the equipment is properly fitted, as can be reached only for short spaces of time by even the most careful manual operation. Regulators operating with electric servo-power have been able to gain admittance of late to all branches of industry, and to an increasing extent, as this kind of control offers quite a number of advantages.

The selection among the various types of regulators available on the market must be made, having regard to the task postulated. On principle, two methods of control may be distinguished: the open-shut control, and the continuous control. In the former the supply of energy is either fully admitted or fully shut off, according to the temperature level, whereas in steady control the quantity of heating or cooling fluid is continually adjusted according to the temperature.

The open-shut control is the simpler of the two, and enters into consideration for all those cases where the plant to be controlled comprises considerable mass and where no currents obtain. Examples: Furnaces, tanks and the like with any desired form of heating, where no circulation of the substance to be heated occurs. Where a circulation obtains, the continuous control must be applied, as is the case with all continuous processes in the chemical industry, as in the temperature control of a heat exchanger or of a distillation column.

Regulator and controlling elements for open-shut control, as also steady control, differ in principle from one another. For open-shut control, expansion regulators, or alternatively regulation with an electric measurement system, will enter into consideration with one of several mercury switches, and for gradual control regulators with impulse contacts, such as the compensation regulator. In order to guard against oscillation in continuous control, it is necessary to operate throughout with return motion. This return motion, in addition, ensures that when appreciable differences in temperature occur the particular plant will aim steadily, without over-regulating, towards the intended value. Control elements for on-off control may be fitted with electro-magnetic drive, whereas for continuous control, valves or butterfly-throttles enter into consideration with power drive.

Dr. O. P. Hood

Dr. O. P. Hood, Chief of the Technologic Branch and Chief Engineer of the Mechanical Division of the United States Bureau of Mines, Department of the Interior, retired recently, and at a farewell luncheon, attended by more than 100 associates and former associates from the Bureau of Mines and from technical and scientific societies, in which he has been active, he was presented with various tokens of appreciation. His retirement completes a quarter century of service, in which he has helped to guide the Bureau of Mines from infancy to maturity. His fine administrative record, as well as his technical achievements, won for him a high position in his profession. He was made a life member of the American Society of Mechanical Engineers in 1935, and in 1932 his Alma Mater, Rose Polytechnic Institute, conferred on him the honorary degree of Doctor of Engineering.

Evolution of the Welded-Tube Industry

By GILBERT EVANS

The history of the development of the welded-tube industry is briefly reviewed. Particular attention is directed to the results achieved by the Fretz-Moon process, and the author briefly describes the cycle of manufacture and makes a comparison with the earlier chain bench and bell die method.

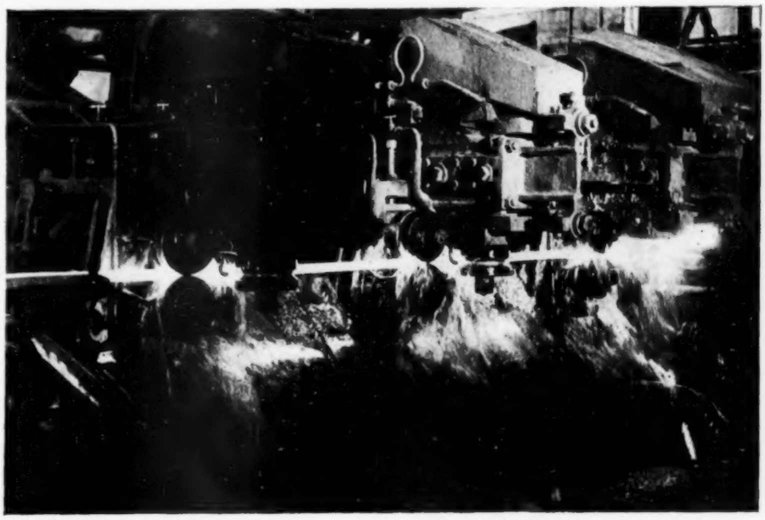
It is probable that no other particular branch of the steel trade can show such development as that of tube manufacture, a statement which applies equally to seamless and welded variety. The first mentioned has at various times been intensely analysed and described, and of late the welded tube trade has attracted the attention of engineers and patentees to such an extent that the author feels justified in recording impressions of a process—the Fretz-Moon—which has completely revolutionised a trade which, in its infancy and up to quite recent years, was regarded as confined purely to the Black Country district adjacent to Birmingham. Briefly described, the welded tube is made from skelp or strip, varying in width and thickness to suit the particular diameter of finished tube required. In both the butt-welded and lap-welded classes the strip is formed into circular shape, and the point of contact welded together under an exceedingly high temperature.

The following historical facts are to be found in "Manufacture of Iron and Steel Tubes," published in 1903 by Edward C. R. Marks. This text-book is the first ever published in this particular branch of the iron and steel trade. About 1812 an engineer, one Osborn, claimed a patent, 3617, for welding by means of an interior mandrel on which the strip was threaded, the combination being subjected to rapid blows under a tilt and/or Oliver hammer. Of necessity, these early tubes were made in comparatively short lengths. From such primitive methods various methods or processes were evolved until eventually the draw-bench period of starting in 1825 saw the introduction of the "Bell" or die method. In this process one end of the strip was cut at a taper to form a long tag, while the rounding die took the shape of a long casting, gradually merging from the flat to a perfectly cylindrical hole.

It is worth while to refer to the humorous situation existing in 1815, when William Murdoch, the founder of gas-lighting, in setting down a gas installation at the Soho Works, near Birmingham, employed old musket barrels screwed together as the means of conveying the gas through out the works. The close of the long European wars had thrown an abundance of such barrels on the market, and they were the most economical form of tubing available for the purpose.

About 1824 the extension of gas-lighting demanded the greater production of iron tubes at a low cost, and inventors were equal to the occasion. James Russell, of Wednesbury, in that year filed a patent specification, No. 4892, setting forth an improvement in the manufacture of tubes for gas and other purposes. He retained the tilt hammer, but the weld could be formed either with or without a mandrel, the edges of the strip butting against each other, not overlapping as in gun-barrel welding, the tube being finished in rolls having circular grooves. The importance of this specification must be emphasised, as it discloses that a sufficiently sound weld can be effected by pressing or forcing the abutting edges of the tube against each other, and no allowance is necessary in the width of the skelp or strip employed as with the lap-welding process.

The tilt hammer was practically eliminated in 1825, when under specification 5109 Cornelius Whitehouse, of Wednesbury, filed a patent which introduced the endless chain draw-bench. The patentee described his process as



[*By courtesy of Deutsche Rohrenwerke A.G.*

Showing the production of welded-steel tube by the Fretz-Moon process.

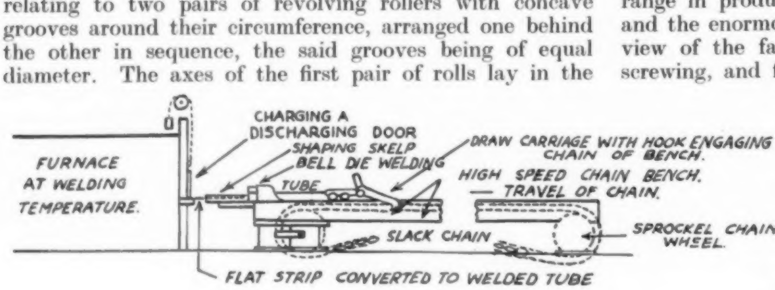
the preparation of a piece of flat iron, called plough plate iron, of a suitable substance and width, according to the intended calibre of the tube. This piece of flat iron was prepared for welding by being bent up on the sides, or, as it is commonly called, turning over, the edges meeting or nearly so, and the piece assuming the form of a long cylindrical tube. This tube was then put into a hollow fire heated by a blast, and when the iron reached the point of fusion, it was drawn out of the furnace by means of a chain attached to a draw-bench, and passed through a pair of dies of the size required, by which means the edges of the iron became welded together.

It is noteworthy that the die employed by the patentee was embodied in an ordinary pair of tongs, or alternatively consisted of a solid die of cast-iron, which was held in a pair of tongs. In either case, the die was held in a position to withstand the drawing or welding process by being abutted against a bracket fitted on the main bed of the endless-chain bench. It was claimed for these tubes that they were capable of resisting greater pressure from the uniformity of the heat throughout at which they had been welded; and that both their internal and external surfaces were rendered quite smooth and greatly resembling drawn lead pipes. Whitehouse's invention greatly reduced the

selling price of gas-pipes, and it became open to all makers and users in 1845.

The foundations of the welded-tube trade were now well laid, and production was commercially established when, in 1829, the success of George Stephenson's "Rocket" created a demand for a larger and stronger form of tube.

In 1840 Richard Povsser was granted patent 8454, relating to two pairs of revolving rollers with concave grooves around their circumference, arranged one behind the other in sequence, the said grooves being of equal diameter. The axes of the first pair of rolls lay in the

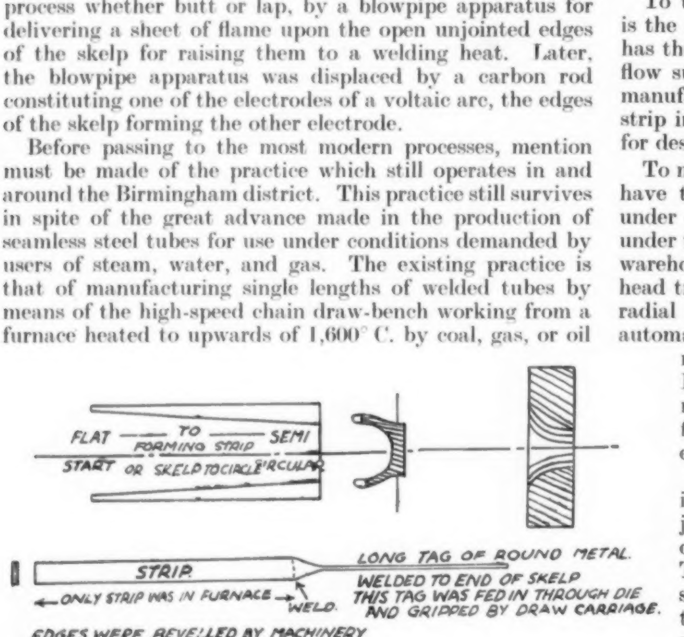


Early practice in tube welding.

horizontal and the second in the vertical, so that compression was exerted equally all round the tube and not merely at top and bottom, as was the case when only one pair of rolls was employed. The skelps, after heating in a reverberatory or other furnace, were passed through the grooved rolls at a uniform speed. An interior support or mandrel was employed in this process. Various patent specifications for patents were filed by John James Russell and Thomas Henry Russell, in conjunction with Cornelius Whitehouse up to 1844, which mainly concern minor details and variations in the tools used.

The first reference to welding by blowpipe apparatus is under patent 5641, dated 1890, invented by Henry Howard, the object being to expedite and simplify the welding process whether butt or lap, by a blowpipe apparatus for delivering a sheet of flame upon the open unjointed edges of the skelp for raising them to a welding heat. Later, the blowpipe apparatus was displaced by a carbon rod constituting one of the electrodes of a voltaic arc, the edges of the skelp forming the other electrode.

Before passing to the most modern processes, mention must be made of the practice which still operates in and around the Birmingham district. This practice still survives in spite of the great advance made in the production of seamless steel tubes for use under conditions demanded by users of steam, water, and gas. The existing practice is that of manufacturing single lengths of welded tubes by means of the high-speed chain draw-bench working from a furnace heated to upwards of 1,600° C. by coal, gas, or oil

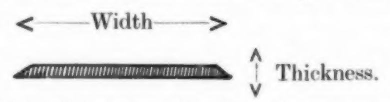


Sketch outline of shaping of skelp and bell shape die in early use.

fuel. Output by these methods is maintained in the production of tubes over, say, 2¾ in. diameter, but on diameters of 2½ in. down to ½ in. the modern plant dealing with strip in coil shape and varying in length from 650–0 in., suitable for ½ in. tube, to 350–0 in. for tubes of 2½ in. diameter. Electric welding has been developed enormously in all branches of the iron and steel trade, and many plants are devoted to the production of tube from strip by this process, but, as an outstanding example of modern development in the particular trade under review, interested engineers are particularly intrigued by results achieved by the Fretz-Moon process, of which process plants are in operation in America, Great Britain, Australia, and in continental works.

This modern development, of which but a faint idea can be conveyed to the reader in the space available, has a range in production from ½ in. to 2½ in. diameter tubes, and the enormous output of the mill can be visualised in view of the fact that each machine in the cutting-off, screwing, and finishing department is capable of dealing with 900 tubes of ½ in. diameter, and 250 of 2½ in. diameter in one hour. The machines are arranged to treat both ends simultaneously. The supply of strip or skelp to the welding machine is maintained from coils varying (according to the finished tube desired) from 350 ft. to 650 ft. in length. As one coil comes to an end an ingenious arrangement allows its tail to be welded to the leading end of a following coil, so that the cycle of feed into the welding furnace is uninterrupted.

The strip is rolled to any desired section in width and thickness, is bevelled at each side of its width, as per sketch :



Section of strip with bevelled edges used in Fretz-Moon process.

which method, it is claimed, produces a better weld, as the two abutting edges are in the same plane when formed just prior to the actual welding. The amount or angle of the bevel is arrived at by the difference between the outer and inner circumferences of the tube.

To the engineering mind the first impression conveyed is the almost total absence of manual labour, so advanced has the mechanisation of the plant been developed. The flow supply and continuity cycle of the various stages of manufacture are uninterrupted from the mounting of the strip in its coiled state to delivery as finished tube, ready for despatch at the finished warehouse.

To maintain such huge outputs, heavy stocks of material have to be carried, upwards of 4,000 tons being stored under conditions which prevent deterioration of any kind under the most adverse conditions. From the raw material warehouse or stock-room the coils are conveyed by overhead transport to the mill, where they are picked up by a radial crane and fed on to a pivoted coil-holder. By automatic appliances the strip is fed into the uncoiling machine, thence to the flash welder and stripper. From the stripper the material is fed to the pinch rolls, down an inclined pit to the magnetic rolls, finally returning in a wide sweep loop to the charging end of the furnace.

To refer back to the flash welder and stripper, it must be explained that this is the point at which junction is made between the tail end of one coil of strip and the leading end of the coil following. This ensures a continuous flow of material. At the stripper any superfluous metal due to the joining of the leading and following strip is removed, leaving a uniform section. During this flash-welding operation the end of the strip is not moving, and to avoid interference with the supply to the furnace the surplus strip in the inclined pit is drawn upon. This method allows a continuous tape or ribbon of strip to be available.

In view of the rate of welding in the forming of the finished tube, it must be obvious that the flash welding of the departing and arriving ends of the coils is merely a matter of seconds of time. Both the welding and stripping operations are automatic, and various gadgets in the shape of pneumatic grips, etc., are brought into use. Extended

tensile tests show that the weld is not the weakest section of the material, as actual fracture takes place away from this point.

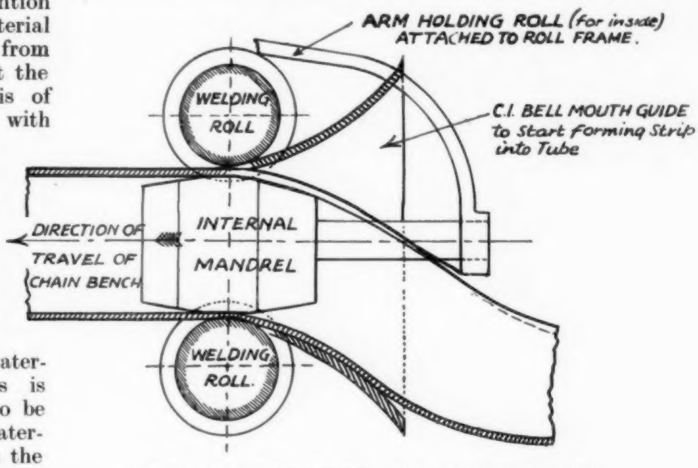
The cycle of progress in manufacture now arrives at the welding furnace, in the design of which special attention has to be paid in the selection of refractory material capable of resisting chamber temperatures varying from 800° C. at the charging end to 1,550° or 1,600° C. at the discharging end. The chamber of the furnace is of box or tunnel section, of great length, narrow, with coke-oven gas as the best heating element. Complete insulation is effected, and the whole is strongly encased. Where possible, the skelp is carried in water-cooled rolls of high heat-resisting properties, as is essential when temperatures up to 1,250° C. discharging end. The chamber of the furnace is of box or tunnel section, of great length, narrow, with coke-oven gas as the best heating element. Complete insulation is effected, and the whole is strongly encased. Where possible, the skelp is carried in water-cooled rolls of high heat-resisting properties, as is essential when temperatures up to 1,250° C. have to be encountered. Each roll is independently driven. Water-cooled skids are also used for carrying the strip, as the conveying of the strip, without contact with the furnace bottom and a likelihood of an adherence of slag therefrom, has to be completely avoided.

Extreme care and supervision has to be exercised in the selection of refractories for the different zones of the welding furnace, and in most cases the selections were made by experts after careful consideration of the actual working conditions. Practical experience is also invaluable in the selection of the type of burner to be adopted. In the case of coke-oven gas, the air nozzles are adapted with spiral vanes to ensure a satisfactory mixing of the air and gas. This adaption eliminated any chance of back-firing. The design and arrangement of spacing of burners and burner-blocks is a matter of importance in the design of the furnace, some experts being in favour of single and others favouring the grouping of three or more burners in the same burner block.

In designing the roof section, preference would be given to this being built in removable sections, a comparatively simple task when the narrowness of the heating chambers is taken into consideration. It is necessary that the doors be of the sealed type and capable of easy control. The matter of recuperators or preheaters is one which again must be controlled by the designer. Local conditions enter largely into the arrangement of the main gas supply, and another matter for consideration is the necessity to ensure equal distribution to the furnace. The provision of suitable observation points are most necessary in the case of a furnace of this type, and there is need for perfect control. Working conditions at such high temperatures are of extreme delicacy, any shortcomings being inevitably reflected in deteriorated quality and interference in output of the mill. Furnace temperature control is essential.

Following the course of the strip through the control. Working conditions at such high temperatures are of extreme delicacy, any shortcomings being inevitably reflected in deteriorated quality and interference in output of the mill. Furnace temperature control is essential.

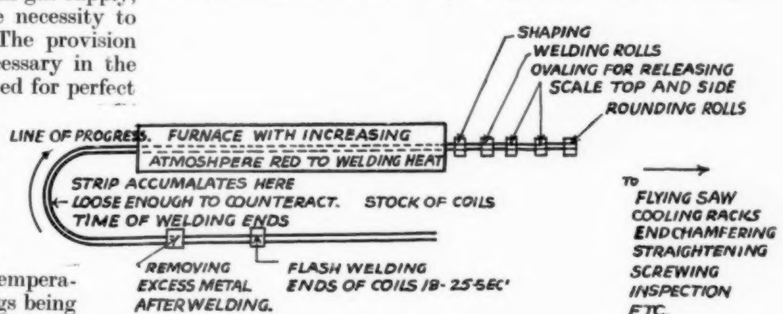
Following the course of the strip through the welding furnace, we have now arrived at the actual welding process in the welding mill itself. This consists in the main of six sets of rolls, arranged alternatively vertically and horizontally, with adjustment up and down or in and out on each roll. The six sets of rolls are geared together, and each stand of rolls by means of overhead gearing maintains the necessary constant peripheral speeds. The first set of rolls—*i.e.*, nearest the outlet of furnace—are termed the forming rolls, where the strip is converted into circular shape, but with the abutting edges not quite closed. Complete circularity and contact of edges is made on No. 2 pair of rolls, at the same time and at the point completing the circle the actual weld is made under pressure of top and



Sketch showing the principle of the bell-mouth method.

bottom rolls. In the remaining four sets of rolls the weld is reduced and consolidated to the desired diameter. The manner in which the rolls are mounted reduces the exact setting to a simple matter, while the changing of rolls from one diameter to another is not a wastage of time.

When it is realised that the output of a mill of this description is from 250 of 2 in. diameter up to 900 of ½ in. diameter finished cut lengths per hour, it is evident that considerable ingenuity was necessary in the arrangement of the saw. This tool travels forward with the tube and makes the cut in its progress, on completion of the cut a recoil spring releases the saw instantaneously and prevents it fouling the oncoming tube. It needs considerable visualisation to grasp all these apparently intricate operations, and a newcomer would be greatly surprised at the ease with which the continuity of manufacture is maintained. The now finished article is passed on to the conveyer for transference to the cooling table or tack, thence to a sizing and descaling mill. In descaling the tube is made into a slightly oval shap in two pairs of rolls, and passed on for sizing in a third roll, which returns it to its absolute circular form Careful attention is necessary at this point, when at a low temperature it is necessary to prevent surface defects



Sketch showing the general layout of the Fretz-Moon process.

due to unsuitable penshal speeds. Methods are adopted to clear the internal surfaces of scale and the like. From sizing and descaling the tubes arrive at a second cooling rack, then on to a conveyer and to a further water-cooled rack to milling machine, after which they are taken charge of by the inspection department. The milling of both ends is done simultaneously, to remove the slightly ragged ends left by the flying saw.

After inspection, and as part of that process, all tubes are tested under a pressure up to 700 lb. per sq. in. The

testing machines are automatic in keeping with the rest of the plant. Treatment is effected in cases where tubes are to be subsequently galvanised or otherwise treated for finish. Where necessary, plant is available for screwing ends, or machines arranged in stagger positions. The usual arrangements are carried out for tensile, and such physical tests as may be specified. It may, in conclusion, be of interest to briefly summarise this latest modern welded tube plant, and also to make simple comparisons with the plant referred to in the opening portion of the article.

CHAIN, BENCH AND BELL DIE METHOD.	FRETZ-MOON PROCESS.
Limited length governed by length of chain bench.	Unlimited length of tube attained by welding separate coils of strip into one length.
Liability to mechanical surface defects owing to contact with furnace bottom in old type of furnace.	Freedom from surface defects. Furnace being average that contact between strip and furnace bottom is eliminated.
Bell dies need replacing after certain amount of wear. Initial cost per die is small.	Longer life of welding rolls, owing to larger circular contact surfaces. The life of tools compensates for extra initial cost of outlay.
Hand labour necessary at all stages.	The control of whole process is practically automatic.
Average time of welding, say, from $\frac{1}{2}$ in. to 2 in. in lengths of 18 ft., $\frac{3}{25}$ secs. on variable speed chain bench, with time for return of dog carriage to die. Approx. under best conditions, 65 ft. to 90 ft.	Continuous supply of skeep. Speeds vary from 98 to 230–0 per minute.
Each separate length of strip has to be tagged for insertion of leading end into Bell die, and engagement with drawing dog.	One tag only needed for continuous supply of strip.
Control of furnace temperature is variable, due to continual lifting of charging and discharging doors.	Furnace temperature controlled by pyrometers.
Results largely dependent on the skill of the welder.	Conditions : Constant freedom from failure to human element.

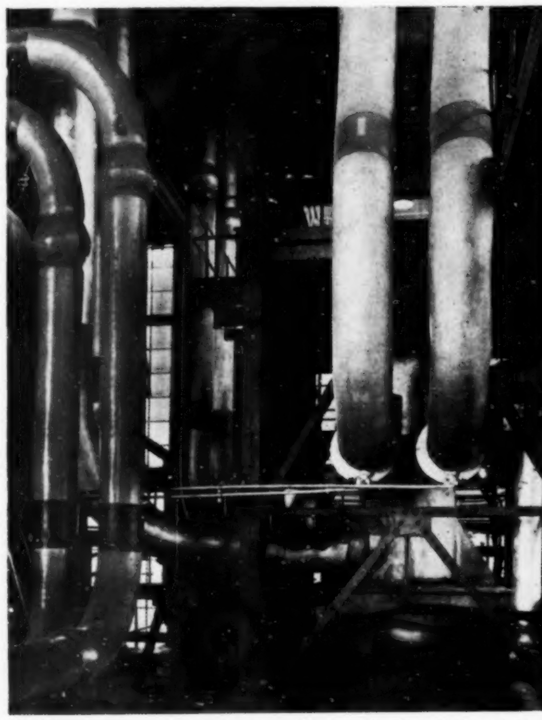
It will have been noted that in the chain-bench process of butt welding the average length of individual tubes is about 18–0 in. The remarks of the director in charge of the Fretz-Moon process were summed up in the following : " We start the plant up at the beginning of a shift, and production is maintained until the end of the day's work or the supply of material is exhausted." With which quotation the author is content to conclude this review of one of the most interesting branches of the steel trade.

High Temperature Insulation

IN connection with the utilisation of waste heat from furnace settings for steam generation in the iron and steel industries efficient heat insulation of the trunking is not easy since many good materials are decomposed at say 500–600° F., and lose their cellular structure.

The ideal covering must possess a variety of properties, including high-heat insulation, high resistance to disintegration by constant contact with the very hot surface, strength and cohesion, easy application, and reasonably light weight. For temperatures within the range of say 600–1,000° F. or over, no single substance, however, combined all these good qualities, and the most efficient coverings, therefore, for high temperature are of a " composite " character.

In this field considerable interest attaches to the work of William Kenyon and Sons, Ltd., who have long manufactured a complete range of coverings. For very high temperature work, such as in connection with the utilisation of waste heat from furnace settings and super-pressure steam with very high superheat, they have available their special asbestos-Kieselguhr (diatomaceous earth) " Kisol No. 1 " composition, which is resistant to temperatures of 1,000° F. or slightly over, and also has good insulation properties. This is placed next to the trunk pipe or other heated surface in a moderately thin layer, say $\frac{1}{2}$ in., to take the first shock of the heat. Following this comes the main bulk of the covering to complete the insulation under much less severe temperature conditions, the best material to use depending upon the conditions. For example, the firm supply their " Kisol No. 2 " asbestos-Kieselguhr composition, 85% magnesia, or asbestos, the nett result being well over 90% heat insulation efficiency.



High-temperature plant showing the application of insulation.

In connection with steam boilers, whether waste heat or otherwise, for most conditions the " No. 1 " composition is not necessary, the " No. 2," for example, being suitable for conditions up to 120 lb. per sq. in. pressure, whilst different methods are adopted for protecting the coverings from mechanical or other damage. For example, hard setting cement may be used, suitably painted, and a high-class job is to include a layer of canvas in the cement which allows of a polished surface. Another typical industrial job also is asbestos sections and " Kisol No. 2 " composition, finished off with embedded canvas.

For the very best results, both as regards appearance and wear, sheet metal is provided for the outer covering along with detachable metal flanges and valve boxes. The firm also specialise in coverings finished in metal since they have an extensive sheet metal business, manufacturing metal trunking for such purposes as mechanical draught, general ventilation and pneumatic conveying, machinery guards, and metal filing cabinets, quite apart from insulation. In many cases sheet metal can be used to great advantage in covering the fronts of " Lancashire " boilers and the drums of the water tube design as well as relatively short steam pipes supplying main engines situated near the boiler plant.

New Methods of Obtaining Double Sulphates of Aluminium and Potassium

A METHOD of obtaining the double sulphate of aluminium and potassium and aluminium and sodium from nepheline tailings, hundreds of thousands of tons of which have so far remained unused in the production of Khibiny apatites, has been invented by a group of workers in the Institute of Applied Chemistry in Leningrad. The double sulphates are used in the paper and textile industries, as well as in purifying drinking water.

Working Copper and Copper-Zinc Alloys

By WILLIAM ASHCROFT

The copper and copper-zinc alloys are discussed from the view-points of hot- and cold-working. The importance of correct annealing is stressed, and the need for temperature-controlled furnaces emphasised.

COPPER and brass sheets and strip, and also rolled or extruded rod, are used to a very large extent as the raw material of many manufacturers, and much work may require to be done upon them in the formation of the many products for which this metal and its alloys are particularly suited. Much of the work of shaping consists of pressing or drop-stamping, and it is proposed to consider some of the difficulties encountered in the shaping of copper and some of the more commonly used brasses. Both copper and brass are shaped hot or cold according to the work to be done and the composition of the alloy when working brass.

Cold-Working Copper

Considerable care must be exercised when cold-working copper. Only thoroughly annealed material should be used, otherwise there is a danger of it cracking. Thus, hard-drawn rods, section and tubes, which are to be compressed, bent, or otherwise shaped cold, if supplied in the hard state, must be annealed before being worked. Even when the material is annealed at the initial stage there is a danger of the material being over-cold-worked in forming the product, and cracking may result. To prevent this, several intermediate annealings may be necessary, which not only increase the cost, but involves much waste of time.

Normally, copper sheets and strip which are to be drawn or pressed are supplied in the annealed state, the annealing being frequently carried out in packs or coils, in which there is a large volume of material with a relatively small surface subjected to oxidation. At the works where the metal is being worked, however, bulk annealing is not so common, and oxidation is generally more prevalent. The oxidation of copper increases with increasing temperature, so that much care is necessary not to exceed, say, 700° C. At this temperature the copper has lost its metallic lustre, and is cherry red in colour. As soon as it has reached this temperature throughout its mass the copper is annealed, and should be plunged into water without delay. This quenching is to facilitate the removal of the oxide coating formed during annealing, and has no effect upon the tensile strength or elongation.

Annealing

It is important that a clean annealing process be adopted in order to reduce oxidation and therefore loss of copper. The oldest and still the most commonly used method is to pack the material in an annealing pot. Pieces of wood charcoal may be placed in the pot so that carbon dioxide may be formed. In another method an inert gas, such as nitrogen, may be used to prevent air coming into contact with the heated copper, or the annealing chamber may be made thoroughly air-tight by means of a water-seal. The latest and best form of annealing is the bright annealing process, in which no oxidation occurs and the surface of the copper preserves the polished surface from its last working process. There are several types of furnaces especially designed for bright annealing copper which are fitted with pyrometric temperature control equipment.

Hot Working of Copper

The hot-working of copper is preferred to cold-working; it is cheaper, and the risk is much less. The operations may be carried out over a wide temperature range of 700° to 800° C. Indeed, in many works it is customary for pressing and rolling to be carried out above 800° C. The higher the temperature the easier the metal flows and less power is consumed in the process, but there is a greater amount of oxidation. It has been found that the tensile strength of copper at 800° C. is only about half that at 600° C.; on the other hand, loss by oxidation at 800° C. is about three times that at 600° C., and with increased oxidation there is greater likelihood of some oxide being worked into the product. The temperature at which the metal is heated therefore is of great importance.

Temperature Control

It is well known that copper is an excellent conductor of heat, that while it absorbs heat readily it is also prone to loose its heat; operations on the heated copper must, therefore, be carried out as quickly as possible. Many factors govern the choice of temperature at which the metal should be heated. Thus, the greater the surface in relation to the mass, the more rapidly will it be heated, and the more readily will it cool during hot-working. The temperature should be kept as high as is consistent with good working, and despite the general practice for operators to gauge the temperature by experience, pyrometric temperature control is to be preferred.

Rapid heating is not necessarily conducive to good work, the important condition to observe is regular heating throughout the metal, so that the flow under hot-working will be regular. Many failures encountered in the hot-working of copper are due to disregarding this basic condition. Temperature and time are therefore the factors which must be observed, and the greater the mass in relation to the surface, the longer will it be necessary to hold the metal at the required temperature to ensure complete soaking. With automatic control of the furnace temperature, it is possible to so adjust the input of gas or electricity to give the most economical working.

The speed of hot-working has an influence upon the success of the operation. Copper is readily rolled and forged hot, but is not so readily pressed; with the copper-zinc alloys containing 62 to 72% copper the position is reversed, actually a transition point occurs between 70 and 80% copper. Normally, the working temperature of copper is approximately 650°–700° C., and this range should be aimed at. A temperature slightly in excess of this will do no harm but with greater increase the risk of failure is increased.

In some instances machining must be done subsequent to the hot-working of the copper, and the operation is not easy if the copper is annealed or the working has been completed hot. A certain amount of hardness is necessary for free cutting, and to ensure this the copper may be worked to some extent in a cooler state.

The Effect of Impurities

Great importance is attached to the impurities present in copper, particularly cuprous oxide from which only electrolytic copper is free. All refined copper contains oxygen, due to the refining process, whilst wirebars or sheets for rolling from remelted electrolytic copper contain it as a result of the melting process. A certain amount of oxygen present in the copper is advantageous, however, since it prevents more injurious gases being absorbed, but copper possesses its maximum conductivity when the

oxygen content is 0·004% ; 0·05 to 0·1% oxygen, equivalent to about 0·2 to 0·4% cuprous oxide, has no effect on the working properties of the copper, but sheet with an excess of 0·1% oxygen is not so suitable for deep drawng. Copper should not be annealed or heated in the presence of unburnt hydrogen, as the hydrogen diffuses into the copper and reduces the oxygen, which may cause fissures in the metal. For this reason copper should not be welded with the hydrogen flame.

Of other impurities present in copper, mention may be made of arsenic, bismuth, and sulphur, each of which influence the metal. Arsenic is frequently intentionally added to copper to produce dense castings. Copper containing about 0·3% arsenic retains its strength at relatively high temperatures, up to about 300° C., and in comparison with pure copper it has a high strength with similar elongation. As a rule, the annealing temperature is higher for arsenical copper. Bismuth exerts a disastrous influence on the properties of copper. Even in very small amounts it forms a eutectic with copper which is present as thin films at the boundaries of the copper crystals. This eutectic is very brittle, and even very small proportions affects the cold-working properties of copper, rendering it cold short. Sulphur in copper is present as cuprous sulphide and lowers the ductility of copper and affects its malleability. When coke-fired furnaces are used for melting, sulphur is invariably absorbed, and the copper is seriously affected in subsequent hot-working.

Copper-Zinc Alloys

A considerable range of alloys is available for working amongst the copper-zinc alloys and alloys containing 52% or more of copper are used in practice. The ease of working and annealing depends upon the crystal structure of the particular alloy. On solidifying, the crystals of copper and zinc vary according to the relative percentages of each metal in the composition. The alloys containing 61% copper and upwards produce α crystals, from 50 to 55% β crystals. Alloys between 55 and 61% copper comprise a mixture of the two types of crystals. Thus the alloys are known as α brasses, β brasses, and $\alpha\beta$ brasses.

The α brasses are readily worked cold, but hot-working can also be performed over a limited temperature range. The β brasses are harder and more difficult to work cold, but they can be worked hot over a wide temperature range, 600° to 700° C., and its hot-working requires less power than the α brasses. The β brasses include the extruding alloy used for many complicated sections which are extruded with difficulty, an alloy containing 52 to 54% copper. This alloy does not work well cold, and should not be bent in the cold state. The $\alpha\beta$ brasses occupy an intermediate position, and include the 58–42 and the 60–40 alloys. The higher the copper content, the better they will work cold, and the more difficult becomes hot-working. Shaping of the 58–42 and 60–40 brasses is almost invariably carried out hot. The work is generally done at a temperature above the $\alpha\beta$ transformation, so that, when cold-working is to follow, annealing is necessary to obtain a homogeneous structure.

The change from β to α crystals necessitates a lengthy anneal at temperatures slightly below the $\alpha\beta$ transformation point, but once β crystals have been formed at a relatively high temperature, whether during hot working or during annealing, they do not disappear on cooling normally in air ; if the material is quenched, the β crystals formed at the particular temperature occur in a greater measure. Thus, if the 63–37 brass is to be worked and deep drawing is involved, it should not be cooled quickly from temperatures above 540° C. Only when annealing has been carried out below the $\alpha\beta$ transformation point may the material be quenched. Alloys with 65 to 66% copper are very difficult to shape hot, since the temperature range in which these alloys lie in the $\alpha\beta$ area is very small and tearing is likely to occur as soon as the temperature falls below the $\alpha\beta$ transformation point.

Working Stresses

In cold-working, internal stresses are frequently set up in the material, and in many cases they cannot be removed economically by a tempering anneal, with the result that the material may crack in subsequent use. In such cases the alloy should have a higher copper content, not less than 85%. Where heating is possible, however, heating at a temperature of about 300° C. is, in most cases, sufficient to remove the working stresses, but the lower the temperature the longer must the stressed material be kept hot.

Although stresses are quickly removed from the material by heat, when further cold work is to be done on it, the time occupied in removing stresses is not sufficient to anneal it in readiness for further heavy deformation. The heavier the deformation under cold work, the larger should be the crystals in the structure, and these require time to develop in the furnace ; at the same time, care must be taken that material which has only been slightly cold-worked is not heated at too high a temperature or for too long a period.

A.C. Motors and Control Gear

No manufacturer in these days of intensive competition will deny the importance of ensuring that his machines are driven with the maximum efficiency This is especially important in the metal trades where the loads fluctuate to a considerable extent. With rapid developments in the use of electrical power and its greater availability, the manufacturer has an easy method of taking power to any part of his works with the least possible inconvenience. Electricity as the power medium allows a separate motor to be employed economically to drive each machine or a particular group of machines, thus eliminating power losses and ensuring that power is only taken from the supply by machines actually in use.

The modern electric motor is quite simple in its essential features, but there are several types, and it is advisable to determine the type most suitable for a given duty. To assist in the selection this informative book, on alternating current, electric motors and control gear, has been published which also gives full details for the installation and maintenance of electric motors. A useful section is devoted to details of horse-power required to drive various machines, and as these are based on 40 years' accumulated experience and have, in the majority of instances, been checked by actual tests, their value will be appreciated. In addition, the book gives wiring regulations and explains in detail the wiring of electric motors to obtain the most efficient results. This book is published at 1s., but readers desirous of having a copy may obtain one free from the publishers, Brook Motors, Ltd., Empress Works, Huddersfield.

Important Developments in the Nickel-producing Industry

The three-year development plan for International Nickel Company's Frood and Creighton Mines, decided on in 1933, was continued throughout 1935, and is being rushed to completion so as to synchronise with plans now under way for increasing ore treatment capacity. Construction of a new smelter unit, to cost $6,000,000, which will include two new reverberatory furnaces, eight new converters, and a new 510-ft. chimney, is now in progress. This, when completed, probably by the end of 1936, will increase smelting capacity by about 40 per cent. The capacity of the concentrator is also being increased for the treatment of 12,000, instead of 8,000, tons of ore a day ; and a research laboratory is to be built at Copper Cliff, in addition to those already in operation at Bayonne, New Jersey, U.S.A., and Birmingham, England. A plant for the manufacture of Monel metal hot-water tanks was established at Port Colborne about the end of the year by Whitehead Metal Products, of Canada, Ltd., a wholly-owned subsidiary of the International Nickel Company.

The Application of X-Rays to Metallurgy.—Part II

By C. HUBERT PLANT

The practical working of X-ray apparatus, and the results which can be obtained without a knowledge of the higher branches of physics, or without having to understand intricate analytical mathematics, are described in this article, and the fundamental principles involved in the application of X-rays to the study of crystals and in the determination of the crystal structure are discussed.

In the first part* of this short series of articles it was shown how the general nature and constitution of X-rays were arrived at, and the article concluded with a short summary of the direction in which Sir William and Professor W. L. Bragg pursued their investigations, following the successful experiment suggested by Professor von Laue.

Space will not allow of a detailed consideration of all the arguments which led up to the equation enunciated by Sir William and Professor Bragg, mentioned in the last paragraph of Section I, which allows the distance separating atom planes to be easily computed ; but it will be necessary to consider the equation itself, as this is the one vital piece of mathematics which has to be taken into consideration. If, in Fig. 4, A B represents a train of X-ray waves, and a crystal X is placed in such a position that the X-rays travel through it, it will be possible to turn the crystal into various positions until a reflected ray X Y will flash out, and will be photographed on the plate Y Z. If D equals the wavelength of the X-rays, d equals the distance separating the atom planes, and θ is the glancing angle made by the rays upon the atom planes within the crystal, while n is any integer, then the Bragg equation is

$$n\mathrm{D} = 2d \sin \theta.$$

It is simple to so arrange conditions that the wavelength of the X-rays is known, and the angle through which the X-rays are bent may be measured ; hence, the distance separating the atom planes can be easily computed. According to the value of n, the reflection is said to be of the first, second, or nth order. One point is of extreme importance—there will be absolutely no reflection on the photographic plate unless the atom planes make precisely the correct angle with the particular wavelength of the X-rays being used. This is a peculiar thing about X-rays : if a wave of light is impinged upon a mirror, it matters not one bit what the length of the wave is, it will be reflected ; but X-ray waves can only be reflected from the atom planes of a crystal, providing those planes receive the X-rays at the correct angle.

To make these statements more clear, let it be supposed that a set of waves on a pond passes over a number of posts, grouped somewhat irregularly as shown in Fig. 5. There will be a jumble of waves around each post, but at some distance from the series of posts there will begin to form a wavelet or ripple of nearly circular form, and if the distance be still greater, the ripple will be much the same as if the group of posts were considered to be one post only ; though even then the perimeter of the ripple will not form a complete circle, but will be somewhat irregular. In the unit cell of a crystal the electrons in the cell may be compared to the group of posts in Fig. 5, and their effect at a distance is much the same as if a single electron only had been involved, so that the whole unit cell can be considered as a representative point, and the formula cited above can apply to a whole crystal as to any one or more electrons.

It must be clearly remembered, however, that the reflection to which reference has been made is not reflection as from a mirror, but is a secondary train of waves caused by the vibration of the electrons in the crystal, due to the impinging X-rays. This secondary wavelength will, however, be exactly equal to the train of waves causing the vibration. This point was mentioned in section one. If, therefore, a beam of X-rays, the wavelength of which is, say, one Angström unit, is passed through a diamond crystal, there will at first, in all probability, be no reflection from the crystal at all, because it is not to be supposed that any one of the sets of planes within the crystal will make the necessary angle with the incident rays. In the diamond there are only fifteen sets of planes which are able to reflect a wavelength of one Angström unit, and in order for there to be reflection the set must make, with the incident ray, the angle proper to that set, as defined by the Bragg formula. When, therefore, the crystal is turned about until there is a reflected wave which can be photographed, the spacing of the planes can be calculated by the formula. The subject of lattice planes will be considered a little later, but if this calculation is made for three sets of planes, which do not all meet in parallel lines, or, as it is termed, do not belong to the same zone, the constants of the lattice can be calculated if the angles which the three sets of planes make are known. By this means can be obtained the first achievement of X-rays in crystal analysis, which no other means could possibly achieve—that of determining the lengths of the lattice cell. This also gives the volume of the unit cell, and knowing the specific gravity of the diamond, a calculation of the contained mass can be arrived at with sufficient accuracy to give the number of molecules it contains.

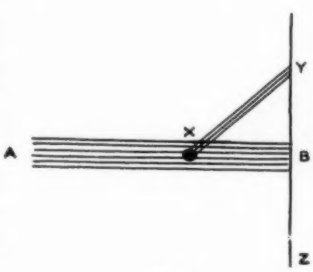


Fig. 4.

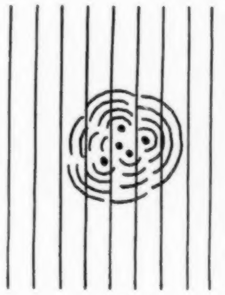


Fig. 5.

It is now necessary to say something about the crystal lattice. This series of articles is dealing primarily with the X-ray crystal analysis of iron and steel, consequently, since these materials crystallise in the cubic system, it is with this class of crystals that it is also necessary to deal In Fig. 6 A B E G D C F H represents a cube, and it will be appreciated that an unlimited number of planes can be drawn through this. In the science of crystallography these planes are always referred to the three axes of the cube—G Y, G Z, and G X. For instance, the plane H A E cuts each axis once, and is referred to as the (111) plane The plane D C F H, or any plane parallel to it, cuts only the G X axis, and is referred to as the (100) plane, while a plane represented by E C D G cuts the G X and G Y—

* July issue.

axes, and is referred to as the (110) plane. Similarly, the (010) set is parallel to the plane E G H F, and the (001) set to the plane G A D H. The points E, F, D, A lie together on a member of the (011) set, adjacent members passing through B C and G H, respectively. All the members are alike in regard to their content of lattice points, though they do not contain equal numbers of those that are shown in the figure. The spacing is equal to the cube edge divided by $\sqrt{2}$; for instance, G A $\sqrt{2}$. Similarly, the (101) set is parallel to the plane E B H D.

Different Types of Crystal Lattice

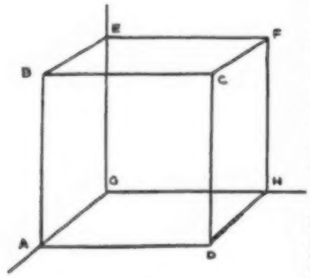


Fig. 6.

There have been recognised some thirty-two different types of crystal lattice, but so far as iron and steel are concerned only two types of lattice are met with. One of these is the so-called face-centred cubic lattice, illustrated in Fig. 7, and this is usually associated with gamma iron. The second-class, shown in Fig. 8, is the body-centred cube associated with alpha iron. In the first type mentioned, the crystal lattice has an atom at each corner of the cube, and one atom in the centre of each face, so that each unit cell contains four atoms. The second class mentioned has an atom at each corner of the cube, and another atom at the centre of the cube, so that each unit cell contains two atoms. As already stated in Section I, the atoms are separated from each other by about one Angström unit, or one hundred-millionth of a centimetre.

It should be made clear that although these two forms of crystal are cubic, the cubic cell is not the unit cell as with a simple cube, for such a cell can only contain or represent one lattice point. One form of the unit cell is shown in Fig. 9, though there are, of course, many other ways of drawing it, and this, of course, refers to the face-centred lattice. A method of drawing a unit cell from the body-centred cube is shown in Fig. 10. It will be seen, therefore, that though the crystal itself is cubic, the unit cell is not so; but it is convenient to retain the cube edges as axes of reference, and the corresponding nomenclature of the sets of planes as already explained.

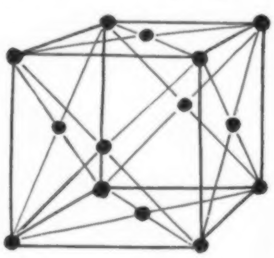


Fig. 7.

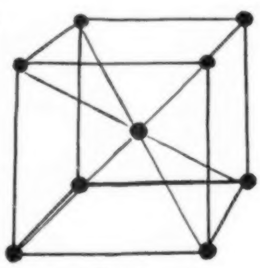


Fig. 8.

When these ideas are understood it is possible to obtain a crystal and introduce it into a beam of X-rays, not homogenous, but made up of waves of different lengths, and every set of planes which makes the correct angle with any of the waves of the X-rays will produce a spot on the photographic plate. When a considerable number of spots are obtained, this is evidence that there are a large number of planes, and the arrangement of the spots enables the form of the crystal to be ascertained, apart altogether from any mathematical calculation which will enable the same information to be ascertained.

The general theories underlying the principles of X-ray analysis have now been shortly considered, but it must not be thought that more than very general principles have been dealt with. It is quite impossible in the space available to enter fully into the various ideas which have been introduced, but it is hoped that enough has been said to show that the principles leading to the practice of X-ray analysis are not so intricate and abstruse as to prevent the understanding of them by the average metallurgist.

Crystal Analysis

Before considering the practical aspect of X-ray analysis it may be as well to obtain an insight into what can be learned from a study of iron and steel by this means. As is well known, every particle of iron and steel that is produced is made up of crystals, arranged in different ways, and in the ternary and quarternary steels these crystals may become very complicated. X-rays provide a tool with which to study these crystals, not only at close quarters, but gives their inner history. It is possible to ascertain their size, the manner in which they are arranged, or orientated, to use a more technical word, and by comparing the different classes of steel, or steel of the same class but of varying constitution, it is possible to glean an immense amount of information regarding the crystal structure. Furthermore, crystal analysis can be utilised for more practical purposes: it is possible to ascertain the effect upon the crystals of stresses imposed upon the metal; it is possible to find out what happens to the crystals under different stresses, and from that conclusions can be arrived at which will indicate what class of metal should be used for certain purposes. With X-ray analysis the whole thing is placed before the observer in one picture, and the absolute foundation of the structure, the atoms forming the crystals of the metal are being photographed. A very good analogy in camparing X-ray analysis with the use of the microscope, chemical analysis, mechanical tests, etc., is to compare it to an architect, a builder, and an engineer going into a great deal of research to discover how long a certain building will withstand certain shocks. Eventually they will be able to ascertain this; but someone is able to come along with one brick of which the building is composed, and to state exactly what that one brick will withstand under every possible condition, from which he can at once state what any given number of bricks will also withstand. The crystal is the brick, from which all iron and steel is produced, and if everything is known about that, then our knowledge of iron and steel itself will be immensely increased.

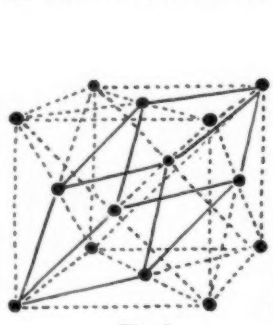


Fig. 9.

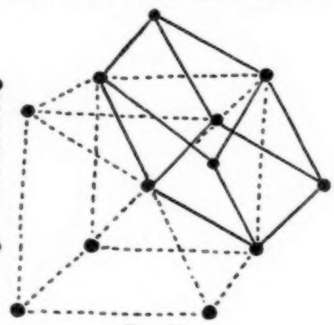


Fig. 10.

Coming now to the more practical side of the subject, there are two methods by means of which crystal analysis can be carried out, and the first to be mentioned is the Laue method. It has already been explained that it is possible to obtain a crystal and introduce it into a beam of X-rays, not homogenous, but made up of waves of different lengths, every set of planes which makes the correct angle with any of the waves of the X-rays will produce a spot on the photographic plate. When a considerable number of spots are obtained, this is evidence that there are a large number of planes, and the arrangement of the spots enables the form of the crystal to be ascertained. At the best, however, it is not possible to obtain single crystals, but a small piece of metal, consisting of myriads of crystals, is the nearest approach to the single crystal that can be used. It should be stated here that single crystals of quite a large size can

be obtained, but not for ordinary practical purposes. If, therefore, a large number of crystals has to be used, the method generally known as the powder method is the one most favoured. If a fine pencil of monochromatic X-rays—that is, X-rays of only one wavelength—is passed through a thin layer of the metal being examined, a set of rings is formed on the photographic plate. The modern method of photography is to use a circular camera, the film being wrapped round the circumference, and the specimen to be analysed being placed at the axis of the camera. Lines are produced on the film, and are actually portions of complete circles; in fact, it is possible to so arrange matters that the complete circle is photographed. Illustrations of these will be given later.

It has already been stated that iron crystallises in the cubic form, and the simplest possible pattern illustrating cubic formation is given by potassium chloride, which produces lines characteristic of the cubic lattice, and which can be recognised by their regular sequence on the photographic film. Each set of atomic planes helps to produce a line, the position of which depends upon the inter-planar spacing. On the other hand, in order to illustrate the point, if sodium chloride is photographed, the pattern on the film is rather different from that of potassium chloride, and is slightly more complicated, because sodium and chlorine atoms are not equal in weight, while potassium and chlorine atoms are. The corresponding lines do not, therefore, occupy quite the same position, the displacements being brought about by the different sizes of the unit cubes of potassium chloride and sodium chloride. The exact size of the cube can be found with an accuracy of about one part in fifty thousand. These two substances have been introduced merely to act as illustration of the results obtained on the film from powder photography.

The method of determining the spacing is mathematical, but as already stated is by no means difficult, in addition to which charts are now prepared by means of which the results can be ascertained with little or no trouble. However, let it be assumed that the film, or that part of it which has been exposed, is terminated at each end by a sharp shadow. It is necessary to measure the distance between the two shadows, and this measurement may be termed S*s*. The distance S between any two lines is also required, and it is found that the best values are obtained by lines near the ends of the film, as these are usually sharper and better defined than those which are near the centre of the film, or if the whole photograph were taken, near to the centre of the rings of circles. The reflecting angle O, already mentioned in connection with the Bragg equation, is related to these measurements by the equation

$$\frac{O}{S} = \frac{Oo}{Ss}$$

The angle O*o* is a constant for the camera, and this is found by means of a calibrating experiment, which need not be entered into now. If the crystal is cubic, as it will be if a crystal of iron is being examined, or the potassium chloride mentioned above, the O value found for each pair of lines can be used to calculate the length of the cube edges from the formula

$$a = \frac{x}{2}\sqrt{\frac{a^2\,b^2\,c^2}{\sin\beta}}$$

where x is the wavelength of the X-rays, and a, b, and c are indices of the reflection producing the lines. It should be pointed out that there are usually errors in the results obtained, due to points which have to be taken into consideration, but these are systematic and can easily be allowed for. The most serious of these is due to absorption of the X-rays, which has the effect of making the calculated error of O greater than it should be. If, however, the powder is pressed into the form of a flat layer, or if flat plates are used in the analysis of metals, discrepancies due to absorption are lessened.

In the next section of this series the general arrangement of the apparatus to produce X-ray photographs will be described and illustrated.

Correspondence

Electric Annealing Furnaces and their Heating Elements

The Editor, METALLURGIA.

Sir,—I have read with interest the article "Electric Annealing Furnaces and their Heating Elements," by Dr. W. Rohn and John E. W. Ginger in your May, 1936, issue. For various reasons, I have not been able to comment before now on the article, but hope you will find room to print this letter in your next issue. In the first place, in spite of the fact that I disagree with the authors on certain points, I wish to congratulate them on an excellent article. They refer to iron-aluminium-chromium heat-resisting alloys, under which heading I presume is included the Kanthal alloys. The typical analysis, given in the article for these alloys, does not contain cobalt which is present in Kanthal alloys, and may account for the differences between the authors' experiences and my own.

I am referring particularly to their suggestion that nickel-chromium alloys are better than iron-aluminium-chromium alloys at low temperatures. This is totally opposite to my experience, which has shown Kanthal alloys to be better than nickel-chromium alloys at both high and low temperatures. Also, with Kanthal alloys at any rate, it is not necessary to heat them up to 1,100° C. to ensure the long life of an element. In fact, I consider this operation to be detrimental because of brittleness which would be developed in the element.

I can give numerous instances of furnaces using elements, consisting of these alloys which have been working successfully for years at temperatures below 1,000° C. without trouble, and whose elements have never been heated to a high temperature before being put into use. Furthermore, Kanthal wire is being sold in this country in large amounts for use in domestic appliances whose working temperature is below 1,000° C.

I am pleased to note that the authors emphasise the advantages of iron-aluminium-chromium alloys for hot plates. Certain makers in this country, and on the Continent, have already fully appreciated this feature of these alloys.

Finally, I can confirm what the authors state so often in their article, namely the necessity for careful design when using these high-temperature alloys. To my mind, many complaints about them are more an admission of bad design than a fault in the material.

HALL & PICKLES, LTD.
J. E. Russell, Works Manager.

The Editor, METALLURGIA.

Sir,—The communication of Mr. Russell is not an easy one to deal with, since it simply confines itself to statements without any argument in support of them. As far as I see it, Mr. Russell bases his remarks upon two factors: (*a*) his own experience, and (*b*) statements that Kanthal is being used in "large amounts" in domestic appliances, and particularly hot plates.

In reply to these two points, I would state that (*a*) Dr. Rohn and myself also have an experience of both types of alloys, extending over several years, and that the results of careful examination of these materials, both in the laboratory and in service, have led us to the conclusions given in our article, for the reasons stated, and (*b*) Mr. Russell gives no indication of what he means by "Large amounts," but the fact is that the amount of Kanthal employed in domestic appliances, although it has been on the market for some years, is still only a small fraction (probably less than 5%) of the quantity of nickel-chromium alloys employed for this purpose, and that, after lengthy trials, the principal hot-plate manufacturers are still utilising nickel-chromium alloys, and not Kanthal.

J. E. W. GINGER.

Reviews of Current Literature

Corrosion Resistance of Metals and Alloys

It is generally recognised that there are two ways by which corrosion of metals and alloys can occur. All reactions, in which metals are transformed into their components under the term corrosion, take place either by direct chemical attack or by electrochemical action. In order to present the facts of corrosion in an orderly manner, however, some classification is necessary, and several methods may be applied. Thus, for instance, a classification is used, based on the corroding conditions, such as: air, acids natural waters, etc. There are certain more or less visible or determinable forms of corrosion which are typical of certain cases of corrosion and not of others, such as: galvanic action, dezincification, pitting, etc. These may be used as a basis of classification. The rate of corrosion has been found to be affected or controlled by certain rate factors, such as: temperature, acidity, electrolytic effects, etc., which are present in most cases, and corrosion may be classified according to these. Then metals have certain properties of direct importance in corrosion, such as: solution pressure, work straining, etc., and corrosion may be classified according to these. Lastly, the metals which are corroded serve as a very practical basis for the presentation of data. This is the method used in the presentation of the corrosion data given in Part II. of this book, where data are grouped under: copper alloys, lead, and lead coatings, etc.

The general form of this work may be considered as based on the properties of the corrosives which cause corrosion, through forms which this corrosion takes, to things which affect the rate, to general properties of the metals themselves which affect their corrosion, and giving finally the specific corrosion resistance of the metals. This is a very brief outline of the manner in which the subject is presented and the various sections are discussed in such a manner that their relation to each other is roughly indicated. The major part of the work is contained in Part II., which gives data and conclusions regarding the corrosion resistance of the metals and alloys, and the metals are classified according to their corroding properties or tendencies. It is undoubtedly true that in the application of this work to industry it would have been more logical and useful to have classified the effect on metal and alloys by various corrosive media, but, as the authors state, present knowledge on corrosion has not advanced far enough to permit such a presentation.

This volume is one of the American Chemical Society series of scientific and technologic monographs. It will be remembered that by arrangement with the Interallied Conference of Pure and Applied Chemistry, in 1919, the American Chemical Society was to produce and publish monographs of this character on chemical subjects. Several have appeared, but it is doubtful whether any so far published have a wider application than the present volume. So intimately are corrosion problems associated with almost every branch of industry that this comprehensive review of knowledge on the subject fills a special need. The authors describe the way corrosion works, based on simple and generally understood concepts which have come to be regarded as facts. The information and data is presented in a concise readable form, which provides a real guide to the procedure in fighting corrosion.

The data mostly concern facts, and it is evident that much work requires to be done on the subject of non-ferrous alloy corrosion, since the authors have not found it possible to give any general methods of prevention. The cure in the majority of cases is to use the right alloy in the right place, and this volume will prove exceedingly helpful as a guide to a suitable selection. In a volume containing so much valuable information it is difficult to portray the lucid manner in which the authors present it, but the following couple of paragraphs, taken haphazardly from one of the chapters will give the reader a clearer conception :—

" This present chapter will deal with two alloys that owe, in large measure, the definite merit they possess to their molybdenum content. One alloy carries 60% nickel, 20% molybdenum and 20% iron, and is a wrought product. The second, more complex, carries, nominally, 58% nickel, 17% molybdenum, 14% chromium, 5% tungsten and 6% iron, and is available only in casting form, of good toughness. Both alloys are widely corrosion resistant, in the sense that the copper and nickel group of alloys, and the chromium alloys are. In addition these two compositions are far more resistant than the other groups to hydrochloric acid solutions.

" Hydrochloric is one of the most corrosive of acids. The chromium alloys are rapidly reactive with it. The nickel and copper metals cannot be considered commercially resistant to it when aerated, hot, or in concentrations higher than perhaps 10%. Furthermore lead and aluminium are not useful with it. These molybdenum alloys are particularly and very usefully resistant to hydrochloric acid."

This book is admirably indexed, which will enable the reader to refer quickly and thoroughly to the data which apply to his problem. A comprehensive bibliography is associated with the work covered in each chapter, which indicates the thoroughness of the search for knowledge on the subject. The authors and the publishers are to be congratulated on this excellent work, which will prove invaluable as a means of reference on corrosion problems to all who use metals.

By Robert J. McKay and Robert Worthington, published by Reinhold Publishing Corp., New York, and Chapman and Hall, Ltd., London. Price 35s. net.

Foundry Calculations and Drawing

Many books have been published which purport to deal with workshop calculations, but, in many instances, it is difficult to understand why the term workshop should be used, and there is always the impression that the authors of such books have had no connection with a workshop. Actually there are methods of calculation which have a general application, but have also a special significance in connection with a particular trade. Rapid methods of calculation occasionally have a special application, and any calculation out of the ordinary often proves attractive to the intelligent apprentice.

It is evident that the author of this book is a practical man and understands the branch of industry to which his methods of calculation apply, not only is he familiar with the pattern shop and foundry, but apparently he has had the opportunity of studying apprentice patternmakers and moulders, for this book is very lucid and devoid of much of the padding frequently used in books of this character. It deals with elementary mathematics, mechanics, sketching and drawing, graphs, weight estimating, and calculating furnace charges. The writer knows of no book of this character in which the information is so ably presented and has no hesitation in recommending it to teachers of workshop calculations and drawing in day and evening technical institutes, It will be found an admirable medium; not only does it give new ideas on a subject with which a teacher is very liable to get into a groove, but it is presented in such a way as to awaken interest in the most difficult student. Only the chapter on mechanics calls for criticism, as, on this subject, the author has adhered to the stereotyped method, when many examples could have been chosen, with profit, from the tools used in the foundry trades; however this is a minor point and does not detract from the value of this book. It is one of a series edited by Dr. Percy Longmuir.

By Leslie Booth, published by Chas. Griffin and Co., Ltd., 42, Drury Lane, London, W.C. 2. Price, 4s. net.

Nickel Steels at Low Temperatures

Recent investigations have been carried out to find a steel of suitable impact strength to use in the manufacture of pressure vessels in a propane solvent plant, in which the temperature may be as low as—60° C. In this article the results are discussed.

AN investigation of the impact properties of 2·25% nickel steel by B. G. Aldridge and G. C. Shepherd resulted from the necessity of finding a steel of satisfactory impact strength for use in the manufacture of pressure vessels, pumps, piping, and valves in a propane solvent plant for the dewaxing of lubricating oils from California crude oil. The propane process normally operates at temperatures varying from 100° F. (35° C.) to − 45° F. (− 42° C.), but in certain cases as low as − 75° F. (− 60° C.) may be attained. As the steel required is used in the form of rather large and heavy rolled plates or castings and must be heat-treated, and as little data was available of the low-temperature impact properties of steel under such conditions, a 2·25% nickel steel was selected for investigation as presenting the least fabrication difficulties, and not being prohibitive in cost.

The impact specimens other than those tested at 70° F. were cooled in an acetone bath, the desired temperature being maintained by the addition of carbon dioxide ice. All the specimens were sub-cooled to a temperature of 3° F. below the desired testing temperature, to compensate for any warming up during the approximate 4 secs. interval between removal of the specimen from the cooling bath and the moment of test. The larger proportion of the impact tests were made on a standard Charpy 217 ft.-lb. machine, calibrated to an angle of rise corresponding to approximately 0·1 ft.-lb., but in certain cases an Izod impact machine was used, which made it necessary to reduce the test results to a common base.

To obtain a relationship between the different types of test-pieces used, a series of tests were made on a normalised and tempered 2·25% nickel steel. These tests include: (*a*) Charpy impact tests to correlate values obtained with the standard A.S.S.T. (American Society for Steel Treating), Charpy impact specimen (keyhole notch), and the standard A.S.T.M. (American Society for Testing Materials), Charpy impact specimens (shallow V-notch); (*b*) Charpy impact tests to correlate values obtained with the standard A.S.S.T. impact specimen of normal 10 mm. width, and standard specimens of 7·5, 5·0, and 2·5 mm. width; (*c*) tests to correlate the U-notch and keyhole notch in Charpy impact specimens; and (*d*) tests to correlate the A.S.S.T. Standard Charpy impact specimen withthe Standard Izod impact specimen. The impact results obtained in this series of experiments show that the influence of the notch is much more pronounced than the influence of areas, or moment of inertia in materials having a relatively low Charpy impact value, and as the Charpy impact value rises, the influence of the area becomes more and more pronounced, and the influence of the notch less and less pronounced. The ratios of the values obtained with the Izod and Charpy specimens increases as the inherent brittleness of the specimen decreases, and the correlation values tend to approach the theoretical values based on the moment of inertia, as the brittleness becomes less and less. The relationship curve for the Izod and Charpy impact specimens is of the same general type as that obtained for the A.S.T.M. and A.S.S.T. Charpy impact specimens, but the reduction of impact value with the more brittle specimens is nowhere nearly as marked in the Izod specimens as it is in the A.S.T.M., and the Izod specimens give somewhat higher values throughout than do the A.S.T.M. specimens, although in both the Izod and A.S.T.M. specimens the influence of the notch becomes more and more pronounced, and the influence of the moment of inertia less and less pronounced as the specimens become more brittle.

Tests made to determine the effect of the direction of rolling on the impact strength of nickel-steel plate showed that values approximately 25% higher are obtained throughout the entire temperature range tested (+ 70 to − 70° F.) from specimens with their major axis longitudinal to the direction of rolling, as compared to those with their major axis transverse to the direction of rolling. The effect of heat-treatment on the impact strength at − 50° F. of a 0·30% carbon, 2·32% nickel, 1⅛ in. steel plate, and at 70° F. and − 50° F. of a 0·25% carbon, 2·25% nickel, 1⅜ in. steel plate showed that normalising at just above the upper critical points results in a marked improvement in impact properties. In the latter steel the directional impact properties are rather persistent and not easily destroyed by heat-treatment, for even after heating to 925° C. and then renormalising at 790° C. the directional impact properties are still quite marked.

In the fabrication of vessels by the fusion welding of nickel-steel plates, tests were made to determine the impact value of the welded plates in the weld and adjacent to the weld, and having the weld transverse to the direction of rolling. In general, satisfactory impact results were obtained, as were also the results of tests made to determine if the change from weld metal to the plate at the fusion line had any effect on the impact value. To determine the effect of plate thickness on the impact value of the steel, tests were made on plates ranging from ⅝ in. thickness up to 1⅜ in. thickness. The test specimens were taken from near the surface and centre of the plates, but no significant difference could be detected, due to the location of the specimens; and over the range of plate thickness tested, the results indicated that the thickness of the plates has no effect on the impact value.

Tests made by maintaining specimens in a bath at − 50° F. for various periods of time, ranging from 20 minutes to 72 hours, showed little difference in the average impact values obtained, while tests made to determine the effect of temperature on the rate of decrease in the impact value of 2·25% nickel-steel showed the impact value to fall off uniformly over the entire range from + 70° F. to − 75° F. Tests made at 70° F. and − 50° F. on specimens taken from five equivalently heat-treated plates of similar nickel content, with carbon ranging from 0·21 to 0·31%, showed that above 0·25% carbon there was some depreciation in the impact value, but at and below 0·25% carbon there was little, if any, change in impact strength.

The heat-treatment adopted for the 2·25% nickel-steel castings was somewhat different from that developed for the rolled plates, due to the persistence of the original "as cast" structure, which proved deleterious to the impact value, particularly at the lower temperatures. It was found that it was necessary to normalise at above 925° C. to thoroughly eliminate the "as cast" structure, and it was also found that renormalising at approximately 815° C. refined the grain and improved the impact values. Castings were tempered at 650° C. after heat-treatment to eliminate any residual stresses due to the normalising treatment.

Tests were also made at −75° F. on a standard 6 in steel pipe containing 0·14% carbon, 0·45% manganese, and 2·33% nickel, on a two-pass weld, on a three-pass weld, and on the affected zone of the pipe. The most

* B. G. Aldridge and G. C. Shepherd. *Metals and Alloys*, 1936, vol. 7, pp. 147-152, 185-192.

satisfactory impact values were obtained after normalising at 815° C. and tempering at 650° C., and showed the pipe to have nearly twice the impact strength of the weld metal. The three-pass weld had a better impact strength than the two-pass weld, and the area of the pipe immediately adjacent to the weld was quite unaffected by the welding.

Suspended Combustion Chamber Walls

FOR a number of years past the suspended wall, like the suspended arch, has been standard practice for water-tube boiler combustion chambers, and the subject is of great importance also for furnaces of all types in the iron and steel and general metallurgical industries. Essentially the principle of the suspended wall is that of a steel framework with cross beams and hangers, on which the firebrick blocks are hung, each one being free to expand and contract and not subjected to undue weight from other blocks.

Seven corrugated blocks holding one another without the overhead supports.

An important advance in this field is the "Detred" suspended wall, a production of the M. H. Detrick Co., Ltd., of London, and the new suspended wall, like the suspended arch, is on the same lines as the standard "Detrick" wall, and interchangeable with it, except that the refractory blocks are half the size, and are made with horizontal corrugations or treads on the two ends and the top and bottom, which intermesh with those of the adjoining blocks, forming interlocking joints. In addition the "Detred" wall is available in two types, "air cooled" and "insulated," and the latter will be described, the only difference, however, being that instead of cold-air circulation insulating material is used behind the suspended wall.

On the usual lines horizontal cast-iron bars are attached at 2 ft. 0 in.–3 ft. 0 in. intervals in the height of the wall to the vertical steel columns of the framework. From these horizontal bars smaller vertical supports are hung each of which has a small shelf or projection which acts as a base for the bottom block in each vertical section, the rest of the interlocking blocks being then added laid horizontally one above the other. Between each of these independent vertical sections of the wall is fitted an expansion joint of the slip type which prevents all leakage of cold air or combustion gases.

The construction also is such that all the vertical joints in each row of blocks are staggered relatively to those above and below, whilst behind the wall the insulating material may be attached in any desired form, such as blocks, in the plastic condition, or as loose material enclosed in sheet metal or other outer cover.

These smaller corrugated "Detred" blocks have a number of advantages as compared with the larger blocks, which also applies to the arches. In the first place the intermeshing of the corrugations gives an absolutely air-tight and gas-tight wall, a most important feature for the very large combustion chambers now used. Spalling, also due to internal strain and to rapid changes of temperature is reduced to a minimum, since there is provision for expansion and contraction and no leakage of cold air takes place.

Further, the use of smaller blocks means that a still higher and more resistant quality of material can be manufactured since the "burning" in the kilns goes uniformly right to the centre.

A New British Chemical Standard

Ni-Cr-Cu Austenitic Iron "L"

BUREAU of Analysed Samples, Ltd., which has recently taken over from Messrs Ridsdale and Co., Ltd., the preparation and supply of British Chemical Standards, announces the issue of the second of a series of alloy cast irons containing special elements.

This standard analysed sample is typical of a type sometimes known as Ni-resist irons which are now being used both for electrical resistance grids and purposes for which high resistance to corrosion at ordinary temperatures, and scaling and growth at high temperatures, is essential.

The standard sample presented more difficulties in analysis than was anticipated and should be useful to chemists who need more information about the accurate determination of high Ni-Cr and Cu and their effect on the determination of the ordinary elements in cast iron.

The standard turnings have been carefully analysed as usual by a number of experienced chemists representing the different interests involved: The British Cast Iron Research Association, Independent Analysts, and Makers and Users of this class of iron.

The standardised figures are as follows :—

	%		%
Total carbon	3·06	Phosphorus	0·119
Silicon	2·26	Nickel	13·45
Manganese	1·01	Chromium	3·96
Sulphur	0·031	Copper	4·73

This is probably the only standard of its kind in Great Britain and is therefore likely to be of interest to independent chemists, government chemists, and works chemists associated with the manufacture or use of alloy irons in the aviation, motor, engineering and electrical industries.

The standard is issued in bottles containing 500, 100, 50, and 25 grns. each, at a price which is estimated to cover the cost. Each bottle is provided with a certificate showing each chemist's analysis together with an outline of the methods he used The standard may be obtained from Bureau of Analysed Samples, Ltd., 3, Wilson Street, Middlesbrough, or from any of the usual laboratory furnishers.

Mining Claim in Southern Rhodesia

THE registration of newly-pegged mining claims in the district of Bulawayo, Southern Rhodesia, during the month of May is an index of the remarkable activity in mining in the Colony. The number of gold reef claims recorded in the area was 1,106, besides 30 rubble and 10 dump claims for the re-treatment of ore previously crushed, treated and abandoned, but in which there is still some unrecovered gold.

Much attention is now being paid to "base" minerals and during the same month no less than 2,340 new claims were registered in the same area, of which 1,860 were for tin, 390 for tungsten ores and 90 for chrome ore.

In Southern Rhodesia the Empire has the largest deposits of chromium in the world. This metal is of vital importance as a war metal, but, thanks to the investigations of metallurgists and chemists, is used for countless peaceful purposes and has come into increasing prominence as an alloy. The amount now consumed is greater even than nickel.

Gas Firing of Metallurgical Furnaces

By a Special Contributor

Considerable controversy exists regarding the subject of high-pressure and low-pressure gas firing of metallurgical furnaces. In this article the author stresses the advantages of low-pressure firing.

TO obtain the most efficient results with all types of gas-fired furnace, setting is much more difficult than is generally imagined. This applies to any type of gas not only hot and dirty blast-furnace gas and producer gas, but also cold and clean gas, such as coke-oven gas, town's gas, and blast-furnace gas, after cooling and purification by electrostatic means.

Many types of burner, for example, do not give a sufficiently intimate mixing of the gas and the air, which require also to be controlled with great accuracy if complete combustion is to be obtained without undue excess air. Also, the flame is often of such a nature that it is impossible to obtain uniform temperature in every point of the combustion chamber space. In addition, the flame may be unstable and liable to sudden " blow-backs " if the conditions alter slightly, such as rate of gas flow or heating of the burner nozzle. Many burners also will not take pre-heated air or hot and dirty gas, in addition to being difficult to clean and complicated to operate.

In this connection great interest attaches to the latest designs of the " Gako " low-pressure burners, a production of Liptak Furnace Arches, Ltd., of London, which are particularly suited for metallurgical furnaces and steam boilers using blast-furnace gas, producer gas, and coke-oven gas (cleaned or uncleaned).

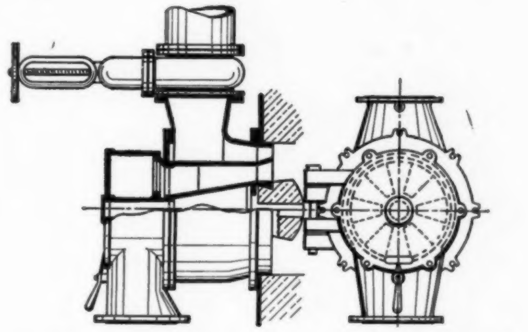
The basic principle of the design is the passage of the air and the gas through the burner in alternate thin layers or streams, one or both of which is given a whirling motion by means of spiral guides and passages, using gas under low-pressure conditions, at, say, 2–4 in. W.G., and cold or pre-heated air as may be desired of similar pressure. Both gas and air also are under separate, very accurate control, with valves on the gas and air-inlet pipes, whilst if high-pressure gas is being used, such as long-distance transmission coke-oven gas, a reducing valve is fitted to reduce the pressure to below, say, 6 in. W.G.

There is much difference of opinion on the subject of the use of low-pressure and high-pressure gas burners. The latter have been evolved to work with gas up to, say, 5 lb. per sq. in. pressure, because long-distance coke-oven gas transmission requires heavy boosting, and is supplied therefore to the consumers' premises at high pressures. These burners also operate on the principle that the whole of the air for combustion is aspirated through the burner by the injection-like effect of the gas pressure, with only one control valve on the gas-inlet pipe.

This high-pressure principle has, however, a number of serious disadvantages, whereas the advantages of low-pressure operation, and of the " Gako " designs in particular, are as follows :—

Accurate Control.—Because of the separate valves on the air and gas-inlet pipes extremely accurate control of the combustion is obtained at all rates of burning. Also, if necessary, the two valves can be connected by linkwork. The principle of controlling both the air and the gas inlet by one inlet valve only on the gaspipe is on unscientific lines, because altering the gas supply does not give a corresponding correct alteration in the air supply. That is, if at a certain rate of high-pressure gas-flow the right amount of air is aspirated through the burner this does not obtain when the gas-flow rises or falls. Under these circumstances the amount of air is either too small or too large, with drop in combustion efficiency, and an accurate proportioning of the value of gas and of air is much too delicate a matter to be carried out on such crude lines as aspiration of air dependent merely on changes in gas-flow.

Stability of Flame.—Arising out of accurate control is the fact that a high-pressure burner gives an unstable flame always liable to " blow back," because an explosive mixture is passing through the burner. Consequently, any excessive reduction in the gas pressure or undue heating of the nozzle causes a blow back. With the " Gako " burner, however, the flame is absolutely stable, even at very low rates of gas-flow, because an explosive mixture is not formed in the nozzle, the gas and air being discharged separately.



A burner for use with blast-furnace gas and air at atmospheric pressure, incorporating an air-control valve and means for creating the desired whirling action necessary for mixing the gas and air.

Uniformity of Heating.—The use of high gas and air pressures necessarily results in a long, narrow " cutting " flame, which causes " stratification " in the combustion chamber space—that is, non-uniform temperature, which means also undue deterioration of the firebrick lining. Because of the intensive mixing of the gas and air the combustion in the " Gako " burners is completed with great rapidity, which produces, also because of the low pressure, a relatively short, globular, and " soft " flame of large size. A row of flames of this type, unlike high-pressure operation, gives no sign of " stratification " in the combustion chamber, whilst also the desired atmosphere—neutral, reducing, or oxidising—is easily adjusted and maintained.

Use of Hot and Dirty Gas.—With this type of low-pressure burner, hot and dirty gas, such as blast-furnace gas and producer gas, can be burnt without difficulty in a manner impossible with high-pressure burners, and the design also is such that every part of the burner is accessible and easily cleaned.

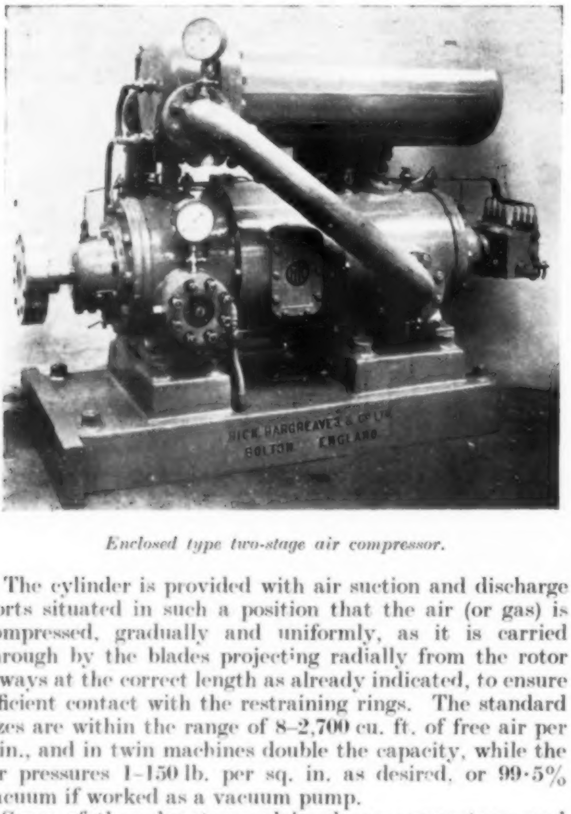
Use of Pre-heated Air.—Also air at any temperature can be used for the combustion, another advantage of separate and accurate regulation of the air supply independent of the gas.

Rotary Air and Gas Compressors

MODERN scientific principles in the field of compressed air are well illustrated by the rotary air or gas compressor, available also for use as vacuum pumps, made by Hick Hargreaves and Co., Ltd. These have a number of notable features, including a series of fully floating restraining rings, roller bearings, and enclosed casing, and are available also as portable units or for permanent installation.

The design is of the positive, multi-chamber, rotary type, consisting of a cast-iron rotor carried on a spindle, running at a very high speed in an outer cylinder or casing. Also the rotor has a number of loose thin steel blades, carried in a series of deep radial slots, these blades being thrown outwards by the centrifugal force so that they always make air-tight connection with the inside of the outer cylinder, irrespective of their position in relation to the space formed at one portion between the cylinder and the rotor, due to the eccentric mounting of the latter.

The tip of the blades, however, do not come into actual contact with the cylinder, but with the floating restraining rings, which are of very slightly less internal bore than the cylinder, these rings also revolving at a high speed, practically the same as the rotor, so as to reduce the friction to a minimum.



Enclosed type two-stage air compressor.

The cylinder is provided with air suction and discharge ports situated in such a position that the air (or gas) is compressed, gradually and uniformly, as it is carried through by the blades projecting radially from the rotor always at the correct length as already indicated, to ensure efficient contact with the restraining rings. The standard sizes are within the range of 8–2,700 cu. ft. of free air per min., and in twin machines double the capacity, while the air pressures 1–150 lb. per sq. in. as desired, or 99·5% vacuum if worked as a vacuum pump.

Some of the advantages claimed are compactness and very small space, easy direct couplings to an electric motor, small steam turbine or other desired drive, continuous flow of air because of the multi-chambers, no valves, small pipe diameter, minimum wear and tear, especially because of the elimination of crossheads, cranks, and connecting rods, and easy adaption to automatic and "distance" electric control.

With regard to constructional details the cylinder or casing is of high-grade cast iron, water cooled if the discharge pressure exceeds 7½ lb. per sq. in., and over 35% vacuum is required in the case of vacuum operation. The rotor also is of cast iron, as already stated, being carried on a steel shaft having roller bearings, while the glands are positively lubricated, using mechanical lubricators operated from the main shaft. When required an automatic pressure governor is provided, while for high-pressure or vacuum the two-stage principle is always used.

As typical of the performance, a two-stage water-cooled direct motor-driven compressor direct coupled to a 70 h.p. motor, running at a speed of 960 r.p.m., has a duty of 310 cu. ft. of free air per min. at 80 lb. pressure. Also a single-stage compressor, direct motor driven as before, with a 40 h.p. motor at 1,440 r.p.m., has a duty of 155 cu. ft. of free air per min. delivered at a pressure of 60 lb. per sq. in., or the maintenance of a vacuum of 27 in. of mercury (barometer 30 in.), whilst handling 125 cu. ft. of rarified air per min. requiring a motor of 11 b.h.p. running at 1,440 r.p.m.

Effect of Impurities on Corrosion Resistance of Solder

THE effect of impurities on solder has long been the subject of controversy, particularly the effect of certain impurities, such as antimony, on the corrosion resistance of solder. The question of the effect of antimony was recently investigated by Hoar,[1] who compared the corrosion resistance of rolled pure tin with that of 5% antimonial tin partly immersed in 0.1 *M* hydrochloric and citric acids and certain tap waters. Hoar observed that the addition of 5% antimony to tin is usually beneficial from the point of view of resistance to corrosion by the liquids used and that there is a slight reduction in the attack by citric acid in the presence of air and a marked reduction in the case of hydrochloric acid. He finally concluded that this work indicates the desirability of incorporating about 5% antimony in tin from the corrosion-resisting standpoint.

These results according to Barber,[2] appear to contradict the well-known fact that antimony acts as a catalyst in accelerating the decomposition of tin alloys in hydrochloric acid, a principle which is utilised on a large scale by the analytical chemist. The question of corrosion is vital to the solder user, and in view of the result obtained by Hoar, the entire problem of the effect of antimony on the resistance of tin alloys to hydrochloric-acid solutions has been investigated by Barber. Although this investigation is primarily concerned with the effect of antimony, copper, and zinc in solder alloys, the pure tin and the antimonial tin-alloys mentioned by Hoar were included. The antimonial solders had the composition 2% antimony–38% tin–60% lead; these alloys may therefore be considered as 40–60% solder made with 5% antimonial tin instead of with pure tin.

As a result of these investigations it is concluded that antimony decreases the resistance of solder to the action of hydrochloric acid and air from 20 to several thousand per cent., depending on the strength of the acid, the time of exposure, access to air, and possibly other factors. The mathematical value of these corrosion differences may be varied widely by an arbitrary selection of conditions.

In very weak hydrochloric acid and under certain ideal or carefully controlled conditions, antimonial solders may acquire a protective film of metallic antimony over the surface of the metal which retards further action to the point where the corrosion rate is about comparable with that of pure solder.

Antimony decreases the corrosion resistance of solder to 0.1 *M* citric acid and air. The addition of 5% antimony to tin makes it much less resistant to 0.1 *M* hydrochloric acid and air. Under no condition was antimony found to increase resistance to corrosion.

Copper and zinc decrease the resistance of solder to the corrosive attack of 0.1 *M* hydrochloric acid under ordinary conditions. This work indicates, therefore, that antimony, copper and zinc should be excluded from tin alloys from the corrosion-resistance standpoint.

[1] Hoar, T. P., *J. Inst. Metals* 55, advance copy (1934).
[2] Barber, C. L., *Ind. Eng. Chem.*, 28. 530–3. 1936.

Business Notes and News

Alluvial Gold Conditions in Southern Rhodesia under Survey

There have been legends in Southern Rhodesia of gold deposits in her Eastern areas. A Blue Book is shortly to confirm or dispel them. A member of the Southern Rhodesian Geological Survey Department has been making a survey of the alluvial gold conditions there, and his report is about to be published.

The story of alluvial gold mining in these parts begins in prehistoric times, but since the occupation of Europeans it has been a record of high hopes and little else. Many of the rivers pass through gold-bearing regions and many of them have gravel containing gold. The extraction of the metal has been interfered with by riparian rights and some of the most likely places are unworked, though tests have proved satisfactory.

The use of the land for agricultural purposes has prevented the introduction of large dredging schemes which have secured good results on the Portuguese side of the border. At the present moment there is practically no alluvial mining in Southern Rhodesia. It is possible that the Government's interest in the matter may lead to a new source of gold supply.

Huge New Ingot Mould

Ever-increasing demands by industry for even larger forgings has led to the casting in Sheffield of a new ingot mould, which, we understand, is the largest in the world. This huge mould was 13½ ft. long as cast, and about 12 ft. wide; it weighed over 150 tons, and seven furnaces were used by the Brightside Foundry and Engineering Co., who cast it, to supply the 160 odd tons of iron required, a further 70 odd tons being used for the base which is 3 ft. 6 in. in thickness.

Ingot mould claimed to be the largest made.

This huge mould was delivered during the night of July 31, to the Atlas Works of Thos. Firth and John Brown, Ltd., and will be used for making ingots up to a weight considerably in excess of 200 tons.

New Rail Car for Southern Rhodesia

Although now fairly common in Europe, the rail-car is an entirely new form of transport in the Rhodesias. The machine, which reached Beira recently, and at once made its way over the Rhodesia Railway's line to Salisbury, is of welded steel throughout. Its weight, in full working order, is 30 tons, and it is propelled by a crude oil Diesel engine of 240 h.p., developing up to 300 h.p. The driving controls, consisting of small levers and buttons, are in duplicate, one set in front and the other at the rear. It is practically vibrationless. It has seating accommodation for 16 European and 40 native passengers, and can carry two tons of mail, parcels and baggage. The exterior of the rail-car is coloured cream and finished in gold, and the internal upholstery is dark-green leather. Powerful headlights are carried, and the car is equipped with horns like those on an ordinary motor-car.

This rail-car has been constructed to specifications prepared by Mr. C. H. Gray, chief mechanical engineer of the Rhodesia Railways.

Honours for Mr. M. E. Leeds

Two important honours have recently been conferred upon Mr. M. E. Leeds, director of the Leeds and Northrup Co., of Philadelphia. In recognition of his great service to society, the honorary degree of Doctor of Engineering has been conferred upon him by the Polytechnic Institute of Brooklyn, and for distinguished achievement in industrial management as a service to the community he has been awarded the Henry Lawrence Gantt Gold Medal.

Dr. Leeds gave up teaching to undertake the manufacture of scientific instruments of precision, particularly those connected with electrical and temperature measurements, which gave him an opportunity of giving effect to his views on human relations in industry, with the result that he is widely known for his far-sighted philosophy of the factors which underlie harmony between employer and employee. The Leeds and Northrup Co., which he founded in 1899, now known throughout the world as manufacturers of electrical measuring instruments for scientific use and of apparatus for industrial measurements and control, has been the proving ground for his ideas. In a growing business, over a period of years, the sound practicability of a progressive managerial policy has been amply demonstrated.

In the Leeds and Northrup plant at Philadelphia, a Co-operative Association in which every employee has a vote, has functioned since 1918. An elected council represents the employees in all their dealings with the management, and in addition has charge of a variety of employee activities over which the management exercises no supervision. Because its meetings are not attended by management's representatives, this council is singularly free to determine employee opinion in its true light, and to express such opinion freely to the officers of the company. For 18 years, council and management have co-operated successfully, both in matters of general policy and in specific instances, to promote mutually satisfactory employer-employee relations.

Specific committees of council investigate matters pertaining to wages and hours, time study, safety, general working conditions, etc. There is an Appeal Board which reviews cases of discharged employees. The Company's wage and salary policy is progressive. The attempt being made to ensure that each man shall receive the equivalent of what he produces. A bonus plan provides a means of extra compensation to those who, through their own initiative and ability, add to the success of the Company.

The voting control of the Company is entirely in the hands of those employees who have purchased employee shares, corresponding to common stock, unless, and until, the fixed dividends on preferred shares have not been earned and paid, in which event, the holders of preferred shares, as well as employee shares, have the right to vote. Thus the Company, of which Dr. Leeds is the founder, has attempted to put into practice a broad policy of justice to all concerned, with equal opportunity for each employee to rise to that level of reward and power for which he is qualified.

North-East Coast Institutions of Engineer and Shipbuilders Awards

The Council of the above Institution have awarded the Engineering Gold Medal to Eng. Comr. C. J. Hawkes, R.N. (ret.), and Mr. G. F. Hardy, M.Sc., for their paper on "Friction of Piston Rings," the Shipbuilding Gold Medal to Mr. R. C. Thompson, M.A., for his paper entitled "Modernising the Motor Vessels Silverpine and Silverlarch and Increasing their Service Speed," and the M. C. James Medal to Mr. W. C. S. Wigley, M.A., for his paper entitled "The Theory of the Bulbous Bow and Its Practical Application."

The Institution Scholarship has been awarded to Mr. Anthony Gilchrist, who is a student of engineering at Wallsend Technical College and an apprentice at the Wallsend Slipway and Engineering Co., Ltd. He will study at the Armstrong College for the degree of B.Sc. in Engineering. The Scholarships of Mr. H. C. Wilkinson, the 1935 Scholar, and Mr. M. Powley, the 1934 Scholar, have been continued for a further year. A prize of £5 is awarded to Mr. R. A. Lyall, who took a high place in the Scholarship Examination.

The Thomas Fenwick Reed Medal is awarded to Mr. W. Pratt, B.Sc., Ph.D., and awards from the Graduate Award Fund, for papers read before the Graduate section, have been made to Messrs. W. Muckle, N. H. Denholm, R. Lowery, G. M. Baker, G. G. Harforth, P. D. Christie and W. H. D. Cookson.

Diesel Oil from Coal

What is claimed to be the world's first plant for making Diesel oil from coal has been opened at Gawber, near Barugh, Yorkshire. The new plant, erected by Low Temperature Carbonisation, Ltd., at a cost of £25,000, specialises in the high-grade oil required for road transport vehicles. Colonel Whiston A. Bristow, chairman and managing director of Low Temperature Carbonisation, Ltd., has no doubt that the Diesel engine is only at the beginning of the movement, which must inevitably result in the displacement of scores of thousands of petrol engines from the road.

The oil produced is also suitable for rail Diesels which have been used abroad for some years and which are now being tried out in this country. It would be a very serious matter for the coal industry if the railways of this country went over to oil unless that oil were provided from our own coal. This is the first practical step in that direction.

Vickers Interim Dividend

The Directors of Vickers, Ltd., announce that the following interim dividends for the half-year ended June 30, 1936, will be paid to the holders of the preferred 5% stock, the 5% preference stock and the cumulative preference stock of the Company, who are registered in the books of the Company on Tuesday, August 4, 1936:—2½% (less Income Tax) on the Preferred 5% Stock. 2½% (less Income Tax) on the 5% Preference Stock. 2½% (free of Income Tax) on the Cumulative Preference Stock.

Payment will be made on Friday, August 28, 1936.

A conveyer-feed screw made in nickel chrome molybdenum cast steel, made at the Stockton Steel Foundry of Head, Wrightson and Co., Ltd., The casting measures 5 ft. long and 5 in. over the diameter of the screw. The type of steel used combines high-tensile strength and toughness with high resistance to wear.

Andrew Carnegie Research Fund

The Council of the Iron and Steel Institute are prepared to make annually a limited number of grants from the Research Fund founded by the late Mr. Andrew Carnegie in aid of metallurgical research work.

The object of the scheme is not to facilitate ordinary collegiate studies, but to enable students, who have passed through a college curriculum or have been trained in industrial establishments, to conduct researches on problems of practical and scientific importance relating to the metallurgy of iron and steel and allied subjects. Candidates, who must be under 35 years of age, must apply before September 30, on a special form to be obtained from the Secretary of the Institute.

The value of the grant will depend on the nature of the proposed research work, but the maximum amount granted in any one year will, as a rule, not exceed £100. The grant will be divided into four instalments. Of these, the first will be paid on or about January 1, and the second and third on or about July 1 and October 1, subject to the receipt of adequate progress reports. The final instalment will not be paid until a complete report on the entire research, in a form suitable for publication, has been received; this should be submitted not later than the following May 31 (in exceptional cases, an extension of an additional year may be granted.)

Messrs. J. Readhead and Sons, South Shields, have received an order for a 9,000-ton vessel from Messrs. Andrew Weir and Co., of London. This is the fourth order this year and means that this firm will shortly have under construction vessels of nearly 40,000 tons in capacity. It is understood that the engines for this new ship will be built by Messrs. Readhead's.

Catalogues and Other Publications

Sternol, Ltd., Royal London House, Finsbury Square, London, E.C. 2, has published an informative booklet, dealing with the modern method of quenching steel, more particularly oil quenching. It contains much information that will be especially useful to heat-treatment departments because it is largely of a technical character. The booklet is a handy size and admirably prepared, and copies are available on request.

A complete range of miniature measuring instruments from 2½–3½ in. in diameter is described in a new catalogue issued by General Electric Co., Ltd., Magnet House, Kingsway, London, W.C. 2. These instruments are available for use on direct current and alternating current circuits and also for particular applications such as cell testing, high frequency current measurements, etc. This catalogue is well illustrated and gives all essential information.

We have received from General Electric Co., Ltd., Magnet House, Kingsway, London, W.C. 2, a catalogue describing a complete range of industrial measuring instruments. These are the larger sizes of indicating instruments and include some of the most delicate types of instruments used in the electric industry. This catalogue is very comprehensive and embraces 88 pages of information.

It is some years since Wild-Barfield Electric Furnaces, Ltd., introduced their patented heavy-hairpin and tubular hairpin furnaces. A large proportion of the orders now received are repeats, many of which are illustrated in a brochure recently issued copies of which are available on request at Elecfurn Works, North Road, Holloway, London, N. 7.

We have received a new booklet entitled "Pre-Treatment for Metal Surfaces," issued by Nobel Chemical Finishes, Ltd., from Imperial Chemical Industries, Ltd., Millbank, London, S.W. 1. The information given in this booklet is of special interest to the metal manufacturer and worker concerned with the ever-present problem of adhesion of paints, lacquers and other finishes—first, as announcing an extension of the Company's technical service into the sphere of metal pre-treatment, and secondly, as giving full details of a range of products and processes developed to solve the common problems of metal finishing. These include the use of A.C.P. "Lithoform" for the pre-treatment of galvanised iron, zinc, and zinc base alloys *in situ*, and of A.C.P. "Granodine" 31 for the pre-treatment of components of the same materials, as well as cadmium-plated surfaces, in mass production work: also of A.C.P. "Electro-Granodine" 30 and "Cromodine" for iron and steel pre-treatments, and A.C.P. "Deoxidine" for preparing and cleaning all iron and steel surfaces prior to painting. The usefulness of the booklet is enhanced by illustrations of treated and un-treated exposure panels, and by the inclusion of a tabulated schedule of all the products dealt with.

With uses ranging from hand-railing to hose mandrils cooling coils to casement rods, pipe mounts to punting poles, aluminium tube is of interest to almost every industry. This gives point to a new booklet issued by the British Aluminium Co., Ltd., "Aluminium Tubes and Pipes."

Common sizes of this form of the metal are set out with weights, calculated in pure aluminium, which do not greatly differ from weights of the aluminium alloys which also are used for tubes. A handy list of aluminium pipe fittings—bends and sockets—forms a supplement to this booklet, copies of which are obtainable from the Company's Head Office at Adelaide House, King William Street, London, E.C. 4.

Further progress in iron and steel production is given in the recent figures for July. Pig-iron production amounted to 661,100 tons, compared with 644,100 tons in June and 547,300 tons in July, 1935. The month's production included 144,700 tons of hemeatite, 386,600 tons of basic, 103,600 tons of foundry, and 9,400 tons of forge pig iron. The production of steel ingots and castings in June was 974,100 tons, compared with 965,900 tons in June and 803,300 tons in July, 1935.

Some Recent Inventions

The date given at the end of an abridgment is the date of the acceptance of the complete Specification. Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, London, W.C. 2, at 1/- each.

Conveying Charges in Metal Heating Furnaces

A METHOD of conveying charges in a continuous furnace for heating metal sheets or plates is illustrated in Fig. 1. A rollerway conveyor is described comprising a series of rollers *a* geared together for rotation at uniform speed, electrically operated means are provided for imparting, at intervals, a high ejecting speed to a variable number of rollers $a^1 \ldots a^{10}$ at the discharge end of the furnace. The driving shaft *d* is connected at one end to the main motor *e* and at the other end to a high speed ejecting motor *f*, a number of free-wheel clutches d^1 being provided to allow the determined number of the ejection group of rollers to be forwardly over-run at high speed. The rollers a^5, a^7, a^9 of this group are earthed while the intermediate rollers a^4, a^6, a^8, a^{10} are insulated and connected to a contactor in the circuit of a motor operating the vertically-sliding discharge door *j*, control switches being provided so that the number of rollers to be speeded up can be varied in accordance with the length of the plates being treated. The short-circuiting, by the forwardly-moving metal sheets, of adjacent rollers in the ejection group effects starting up of the motor operating the door *j*, the latter, on reaching its fully-raised position, closing a contactor to switch in the high speed motor *f* and thus speed up the determined number of ejection rollers. When the sheet being ejected bridges the last two rollers a^1, a^2, a coil is energized to open a switch in the circuit of the door-operating motor and allow the door *j* to close ; during this closing movement the door actuates a further switch to cut out the motor *f*. Hand-operated switches are provided to allow of non-automatic speeding-up of the ejection rollers and to permit emergency stoppage and restarting of the entire conveyor. Specification 429,626 is referred to in the Provisional Specification.

430,833. J. FALLON, British Mills, Cornwall Road, Smethwick, near Birmingham. [Class 51(*ii*)].

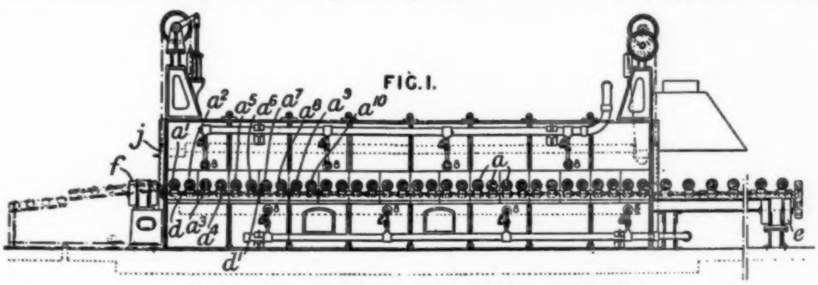


Fig. 1.—Conveying charges in a metal heating furnaces.

Flux for Aluminium

A FLUX for aluminium and its alloys is prepared by mixing zinc chloride with sodium fluoride with or without potassium fluoride in the presence of water, so that zinc fluoride is formed and sodium or potassium chloride. The zinc chloride may be partly replaced (up to 10%) by magnesium chloride, and the sodium or potassium fluorides may be partly replaced (up to 20%) by the phosphates or borates. To reduce the melting temperature of the flux and increase its stability under heat, chlorides of barium and strontium may be added, and to increase the reactivity of the flux sodium or potassium permanganate, chromate, or sulphate may be added.

435,279. H. C. HALL, Pastures Avenue, Littleover, Derby. [Class 82 (*i*)].

Phosphate Coatings on Metal

METALS which are to be coated with a surface layer of phosphate by treatment with phosphoric acid or a solution of phosphates are subjected to a preliminary treatment by immersion for a period of from a few seconds to a few minutes in a dilute solution of a copper salt—*e.g.*, the sulphate, or a nickel salt, or a solution containing both a copper salt and a nickel salt. The metal may be given a treatment in a solution of a zinc salt prior to the treatment in the copper or nickel salt solution or a zinc salt may be added to the solution of the copper or nickel salt. An electric current is preferably employed to hasten the action, the article being made the cathode. The conditions of the preliminary treatment are such that no definite plating is formed, but the metal is given a smooth surface which improves the adherence of the phosphate coating. When a preliminary treatment in a zinc salt solution is employed a solution containing zinc sulphate, common salt, boric acid, aluminium sulphate, and dextrine may be used. The phosphate coating may be formed by using a bath of phosphoric acid or iron phosphate with or without metallic iron. Other phosphates such as chromium, nickel or copper phosphate may be added to the bath. After the phosphate coating has been formed the treated metal may be immersed in oil at ordinary or at elevated temperature. According to the first Provisional Specification an electric current may be used during the phosphate treatment and according to the second Provisional Specification the preliminary treatment may comprise the deposition of any metal—*e.g.*, zinc, either by electrolysis or by simple immersion.

438,816. H. T. DAVIES, 12, Henrietta Street, Covent Garden, London. [Class 82 (ii)].

Colouring Zinc Surfaces

A METHOD has been developed for colouring the surfaces of articles which are coated with zinc, or composed entirely of zinc or zinc alloys, in which zinc is the main constituent. The surfaces are treated with a reagent which will produce an adherent zinc compound on the surface and this surface compound is then dyed or coloured. The reagent may be an acid—*e.g.*, a mineral acid such as sulphuric, or acid such as oxalic, citric, succinic, sulphurous or hydrosulphuric, or it may be a caustic alkali or hydrogen peroxide. The articles may be pickled in mineral acid or otherwise cleaned prior to the formation of the surface compound, and after dyeing are rinsed, preferably in soft water. In some cases the article after dyeing may be immersed in boiling water. The article is then allowed to drain and dry, and may be placed in a current of warm air at 80 to 100° C. The dyed coating may then be polished or may be sealed with lacquer, wax, etc. The treatment of alloys consisting of : (*a*) zinc, 4·1% of aluminium, 2·7% of copper, and 0·03% of magnesium ; (*b*) zinc, 4·1% of aluminium, and 0·04% of magnesium ; and (*c*) zinc, 4·1% of aluminium, and 1·25% of copper, is described, the reagents being hydrosulphuric acid for the alloy (*a*) and oxalic acid for the alloys (*b*) and (*c*). The treatment of rolled zinc sheet is also described, the reagents being concentrated sulphuric acid in one example, and hydrogen peroxide in another. As dyeing or colouring agents Anodic Blue, Vandyke Brown, Brilliant Orange, Acid Green and Rhodamine 6 G.B.S. are referred to.

440,033. P. S. LEWIS, St. Andrews Road, L. A. J. LODDER, Avonmouth Road, both of Avonmouth ; and NATIONAL SMELTING CO., LTD., Gresham Street, London. [Classes 82(*i*), and 82 (*ii*)].

MARKET PRICES

ALUMINIUM.

98/99% Purity		£100 0 0

ANTIMONY.

English		£65 10 0
Chinese		51 0 0
Crude		24 10 0

BRASS.

Solid Drawn Tubes	lb.	9¾d.
Brazed Tubes	„	11¾d.
Rods Drawn	„	8⅞d.
Wire	„	7⅞d.
*Extruded Brass Bars	„	4½d.

COPPER.

Standard Cash		£38 7 6
Electrolytic		42 10 0
Best Selected		41 10 0
Tough		41 0 0
Sheets		70 0 0
Wire Bars		43 0 0
Ingot Bars		43 0 0
Solid Drawn Tubes	lb.	10¾d.
Brazed Tubes	„	10¾d.

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0 3 1½
‡Ferro Tungsten	„	0 3 0
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.		
NOMINAL: 2–4% Carbon, scale 11/- per unit	ton	29 15 0
NOMINAL: 4–6% Carbon, scale 7/- per unit	„	22 7 6
NOMINAL: 6–8% Carbon, scale 7/- per unit	„	21 12 0
NOMINAL: 8–10% Carbon, scale 7/- per unit	„	21 12 0
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steel-work. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit	„	33 10 0
Guar. max. 1% Carbon, scale 12/6 per unit	„	36 5 0
§Guar. max. 0·5% Carbon, scale 12/6 per unit	„	37 5 0
‡Manganese Metal 97-98% Mn.	lb.	0 1 2
‡Metallic Chromium	„	0 2 5
§ Ferro-Vanadium 25–50%	„	0 12 8
§ Spiegel, 18–20%	ton	7 10 0
Ferro Silicon—		
Basis 10%, scale 3/- per unit	ton	6 5 0
20/30% basis 25%, scale 3/6 per unit	„	9 0 0
45/50% basis 45%, scale 5/- per unit	„	12 5 0
70/80% basis 75%, scale 7/- per unit	„	17 6 6
90/95% basis 90%, scale 10/- per unit	„	28 17 6
§ Silico Manganese 65/75% Mn., basis 65% Mn.	„	12 5 0
§ Ferro-Carbon Titanium, 15/18% Ti	lb.	0 0 4½
Ferro Phosphorus, 20–25%	ton	22 0 0
§ Ferro-Molybdenum, Molyte	lb.	0 4 6
§ Calcium Molybdate	„	0 4 2

FUELS.

Foundry Coke—		
S. Wales	—	1 10 0
Scotland	—	1 10 0
Durham		1 4 6
Furnace Coke—		
Scotland	—	1 5 0
S. Wales	—	1 5 0
Durham	—	1 1 6

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)		£60 10 0
*Commercial Ingots		45 0 0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0 0 9
*Cored Bars	„	0 0 11

LEAD.

Soft Foreign		£16 12 6
English		18 15 0

MANUFACTURED IRON.

Scotland—		
Crown Bars, Best		£10 5 0
N.E. Coast—		
Rivets		10 10 0
Best Bars		10 2 6
Common Bars		9 5 0
Lancashire—		
Crown Bars		9 12 6
Hoops	£10 10 0 to	12 0 0
Midlands—		
Crown Bars		9 12 6
Marked Bars		12 0 0
Unmarked Bars	from	7 5 0
Nut and Bolt Bars	£8 10 0 to	9 0 0
Gas Strip		10 12 6
S. Yorks—		
Best Bars		10 15 0
Hoops	£10 10 0 to	12 0 0

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards—Solid	lb.	9d.
*Cored Bars	„	11d.
†Strip	„	11¼d.
†Sheet to 10 W.G.	„	11¾d.
†Wire	„	1/0⅜
†Rods	„	10¾d.
†Tubes	„	1/2
†Castings	„	1/0½

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—		
Hematite M/Nos.		£4 5 6
Foundry No. 1		4 1 6
„ No. 3		3 19 0
N.E. Coast—		
Hematite No. 1		4 5 6
Foundry No. 1		3 17 6
„ No. 3		3 15 0
„ No. 4		3 14 0
Silicon Iron		—
Forge		3 14 0
Midlands—		
N. Staffs Forge No. 4		3 17 0
„ Foundry No. 3		4 0 0
Northants—		
Foundry No. 1		4 3 0
Forge No. 4		3 14 6
Foundry No. 3		4 0 0
Derbyshire Forge		3 17 0
„ Foundry No. 1		4 3 0
„ Foundry No. 3		4 0 0
West Coast Hematite		4 5 6
East „ „		4 5 6

SWEDISH CHARCOAL IRON AND STEEL.

Pig Iron	Kr. 110	
Billets	Kr. 240-310	£12 7 6–£16 0 0
Wire Rods	Kr. 290-340	£15 0 0–£17 10 0
Rolled Bars (dead soft)	Kr. 200-220	£10 6 0–£11 7 0
Rolled Charcoal Iron Bars	Kr. 290	15 0 0

All per English ton. f.o.b. Gothenburg.
Converted at £1 = Kr. 19.40 approx.

SCRAP METAL.

Copper Clean		£29 0 0
„ Braziery		26 0 0
„ Wire		—
Brass		19 0 0
Gun Metal		28 0 0
Zinc		9 0 0
Aluminium Cuttings		74 0 0
Lead		13 10 0
Heavy Steel—		
S. Wales		3 5 0
Scotland		2 17 6
Cleveland		2 17 6
Cast Iron—		
Midlands		2 12 6
S. Wales		2 17 6
Cleveland		3 5 0
Steel Turnings—		
Cleveland		2 0 0
Midlands		2 0 0
Cast Iron Borings—		
Cleveland		1 7 6
Scotland		1 17 6

SPELTER.

G.O.B. Official		—
Hard		£11 5 0
English		14 5 0
India		12 10 0
Re-melted		13 0 0

STEEL.

Ship, Bridge, and Tank Plates		
Scotland		£8 15 0
North-East Coast		8 15 0
Midlands		8 17 6
Boiler Plates (Land), Scotland		8 10 0
„ „ (Marine) „		—
„ „ (Land), N.E. Coast		8 10 0
„ „ (Marine) „		8 17 6
Angles, Scotland		8 7 6
„ North-East Coast		8 7 6
„ Midlands		8 7 6
Joists		8 15 0
Heavy Rails		8 10 0
Fishplates		12 10 0
Light Rails	£8 10 0 to	8 15 0
Sheffield—		
Siemens Acid Billets		9 2 6
Hard Basic	£6 17 6 to	7 2 6
Medium Basic	£6 12 6 and	7 0 0
Soft Basic		5 10 0
Hoops	£9 10 0 to	9 15 0
Manchester		
Hoops	£9 0 0 to	10 0 0
Scotland, Sheets 24 B.G.		10 10 0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten	lb.	2/-
Finished Bars 18% Tungsten	„	2/9
Extras		
Round and Squares, ½ in. to ¼ in.	„	3d.
Under ¼ in. to 3/16 in.	„	1/-
Round and Squares 3 in.	„	4d.
Flats under 1 in. × ⅜ in.	„	3d.
„ „ ½ in. × ¼ in.	„	1/-

TIN.

Standard Cash		£184 5 0
English		184 0 0
Australian		184 5 0
Eastern		183 5 0
Tin Plates I.C. 20 × 14 box		18/9

ZINC.

English Sheets		£24 0 0
Rods		25 10 0
Battery Plates		—
Boiler Plates		—

*McKechnie Brothers, Ltd. Aug. 12. † C. Clifford & Son, Ltd., Aug. 12. ‡ Murex Limited, Aug. 12.

Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.

§ Prices ex warehouse, Aug. 12.